AFFORESTATION

SOUTHERN LANDS

E. MAXWELL

AFFORESTATION IN SOUTHERN LANDS

DEALING SPECIALLY WITH

LOCATION AS TO MARKET, SYSTEM AND METHODS OF PLANTING, SYLVICULTURAL TREATMENT AND SPECIES MOST SUITABLE FOR SOUTHERN LANDS

BY

E. MAXWELL

Consulting Forester

WITH A FOREWORD BY

HON. G. M. THOMSON, M.L.C., F.L.S.

WHITCOMBE & TOMBS LIMITED

AUCKLAND, CHRISTCHURCH, DUNEDIN, WELLINGTON, N.Z.
MELBOURNE, SYDNEY, LONDON

FOREWORD.

Afforestation and preservation of existing forests are matters of such vast importance to New Zealand that we welcome all information which will assist in the development and utilisation of our forest resources. The timber supplies of the world are being so rapidly diminished that pessimists predict an absolute famine within a very few decades. The demand for timber is not showing any signs of falling off, though the price of it continues to soar, and though substitutes in the form of concrete and steel are being utilised in many ways. But these can never take the place of wood in furniture and cabinet-making, nor is there any present substitution of them for fruit and butter cases. Paper-making from wood pulp is at present a great industry in Canada and part of the United States, but even in these lands the end is in view, and the disappearance of vast areas of existing forests is only a question of time. And there is nothing to replace them in sight at present. The only very great forest region of the world at present is South America, but while there is no doubt a most extraordinary amount and variety of timber in that vast continent, the utilisation of it is a problem which may prove insoluble, at any rate for a very long time.

The demand for paper is constantly increasing, and while the pulping of wood is proving a comparatively easy method for its manufacture, it is not likely to prove very permanent. Where timber is abundant, as in Canada and parts of the States, wood pulp will be produced in quantity, but in this country and in Australia the price of labour may prove prohibitive, and trees must be grown, as a payable proposition, for their timber alone.

The cultivation of forests for water conservation will always be a most important feature in our political economy, but in such developments the commercial value of the timber and its secondary products is a secondary consideration.

In New Zealand private tree planting has been rather sporadic, and of late years the artificially enhanced price of land has rendered all but shelter planting almost impossible. But the State has for many years been developing a forest sense, and has encouraged planting throughout the Dominion, quite apart from the extensive areas which have been planted in the State nurseries. Recently also many company schemes have been promoted, considerable areas have been taken up,

and planting operations have been commenced. But even yet all that has been done is small when compared with the future timber needs of the country, and the possibilities of a great export trade in the years to come.

A survey of the geographical and meteorological conditions, especially of the Southern Hemisphere, seems to point out New Zealand as pre-eminently a country in which timber growing should be a most important industry. Originally a forest-covered country, its timber supplies have been most ruthlessly destroyed in the past. Recently steps have been taken to conserve what still remains, but the hope for the future lies in planting new areas.

To educate the people to a sense of the importance of timber growing, information from all available sources must be secured. It is therefore with pleasure that one welcomes a book on afforestation, dealing with New Zealand conditions and possibilities. Mr. E. Maxwell has devoted much attention to the subject for many years past. He has cultivated most of the trees suitable for New Zealand planting, and with the love of a true naturalist has carefully noted their characteristics. Many men observe natural phenomena, but unfortunately only a comparatively small number commit their observations to paper. Consequently the value of this first hand information collected by a competent observer over a long period of years is very considerable.

In this work on Afforestation Mr. Maxwell deals only with the planting and cultivation of exotic trees, and chiefly with those introduced from California and Australia. He barely mentions European trees, because numerous treatises dealing with them have been published. He is interested in such species as he considers suitable for economic planting, and his information will be found to be very useful, and much of it not accessible to the average reader. Incidentally the State Forest service comes in for a good deal of hard criticism, much of it—referring to errors committed in past days—well deserved. But the Department as now constituted is doing good work, not only in forest conservation, but especially in connection with by-products of forest growth. The failures of the past will no doubt be avoided as far as possible, and criticism from an ardent arboriculturist like Mr. Maxwell cannot hurt, but may furnish useful ideas which are worthy of adoption.

I commend this book to all who are interested in trees and their culture, and to those who are concerned in the development of the country on sound economic lines.

GEO. M. THOMSON.

PREFACE.

The following presents some indication of the subjects pertaining to afforestation that are dealt with in this work, and it is also a summary of what should, under intelligent direction and with good work, ensure economic and financial success in afforestation undertakings:—

1. Location near the market and ease of access.

2. Situation as favourable as can be to healthy rapid growth of the species, the produce of which is required and which will most readily find a market.

3. Choice of species and type most suitable taking into consideration the situation and the prospective market.

4. Selection of seed from vigorous growing best right type trees which are growing under conditions most similar to those obtaining where the plantation is to be raised.

5. Raising of sturdy, short, well-grown young plants with plenty of fibrous roots. Proper, thorough wrenching. Careful handling and grading. Treatment of roots so as to prevent twisting, crossing, bending over, or crushing together, and keeping moist at all times.

6. Careful deep planting, firming of soil round the roots below the crown, but the leaving loose of soil round the stem and on the surface.

7. Thorough cleaning, and where possible, deep ploughing, etc., of area before planting.

8. Designing and laying out of plantations so to facilitate as fully as possible all working in the forest and removal of all material from it.

9. At all times to aim at the production of the largest possible proportion of highest grade timber to that of low grade, irrespective of the class of timber.

10. Dense systematic planting.

11. Maintenance of fully stocked stands.

12. "Mixed" planting wherever practicable in preference to "pure."

13. Thinning, followed by intermediate cuttings throughout practically the whole rotation period, at times and to degree—rather under than over—required.

14. Shelter and protection of margins both against wind and fire.

15. Protection against fire and provision and organisation to cope with outbreaks.

16. Absolute exclusion at all times from the actual plantations and surroundings of cattle of any kind and of trespassing persons.

17. The employment of qualified and experienced advisers (especially those with local experience).

CONTENTS

LIST OF ILLUSTRATIONS

Forestry in Southern Lands

Chapter I.

OBJECT.

The object of this work is that it may be a general guide towards successful afforestation operations in Southern Lands—New Zealand, Australia, and South Africa—but more especially in New Zealand.

Very many valuable works exist dealing with the principles and practices of forestry, and with allied sciences and industries, but they deal almost entirely with forestry and sylvicultural practices applicable to the countries of the Northern Hemisphere, and so are based largely on experiences there, and deal with species of trees—mostly very slow growing—which are suitable to those countries.

Though the fundamental principles of forestry are applicable, as a guide, the world over, the entirely different climatic and other conditions, the extremely rapid growth and the different species of trees to be dealt with in our southern lands, entail very different methods and practices from those dealt with in those works, and unfortunately there is no work dealing with these southern conditions* and very little recorded data of any value dealing with the growth, under varying conditions, sylvicultural and otherwise, of the various species important for afforestation purposes in these climes, and the writer's desire has been to make available the results of some forty odd years of observation, study, and practice in connection therewith.

As a guide to right and to avoidance of wrong methods and practices it has seemed advisable to make marked reference to the most obvious errors of the past and to unsound methods and lack of proper sylvicultural practices in some State and

*Since this was written a valuable work, *Tree Planting in South Africa*, by Dr. T. R. Sim, of Maritzburg, Natal, has been issued.

other afforestation operations. These embrace the following:—Wrong location, wrong choice of species, failure to carry out experiments of any real value (except to some extent in South Africa), too open planting, wholesale "pure" planting instead of "mixed" thus courting disaster from diseases and insect pests, and lack of recognition of the vital importance of thinning.

Besides many general works on forestry and allied sciences and industries, there are also many such dealing with separate branches or associated subjects, such as insect and fungoid pests, preservation of timber, etc. On such subjects research, experimental, and other work is being carried on in each of the southern lands—New Zealand, Australia, and South Africa—the results of which are published and made available from time to time, and therefore necessarily provide a far better source of reliable up-to-date information on the particular subjects than could be afforded in any general work or by one such as this which is intended more as a guide to afforestation operations than on forestry generally.

Chapter II.

FORESTRY.

The art and practice of forestry dealing with afforestation on scientific lines so far as applicable to southern lands is yet quite in its infancy.

That further advance has not been made is due to several causes, chief among which has been the lack of what may be termed, a forest conscience, which lack has naturally resulted in much political apathy, if not actual discouragement.

That this condition of affairs so far as the effect in Australia and New Zealand, especially in New Zealand, has been due to the lavishness with which nature had endowed these countries with forests is evidenced by the fact that South Africa, which had not been so well favoured by nature, has done much more proportionately, especially considering its disadvantages, than Australia or New Zealand, and has secured, and recognized the value, and made better use, of trained talent.

Political apathy, niggardliness, and discouragement has, for the greater part, thwarted the efforts of those qualified to advise and guide operations on sound lines, with the result that, though considerable afforestation has taken place, much or almost all, excepting that in South Africa, has been more or less "rule of thumb" tree planting, with utter disregard of sylvicultural considerations and of economical exploitation.

Under these circumstances it is not surprising that no practices have been followed from which the all-important data could be collected upon which to ground soundly conducted afforestation operations dealing with the species of trees most suitable under the climatic and other conditions for economical timber production in these southern lands, and also as a consequence there does not so far exist any work on Forestry generally applicable to these lands.

The sooner it is recognized by the taxpayers and others in Australia and New Zealand that forestry does not consist in planting thousands of acres of poor land, no matter how remote or practically inaccessible, sparsely with some sort of trees, and with entire neglect of all sylvicultural considerations, leaving them to grow or die as best they can with the idea that they will produce timber of value, is not forestry, the better hope for a sounder system and better practices.

It would be just as reasonable to suppose that the acquiring of canvas, paint, and brushes, ignoring the need of any art by the one using the brushes, would result in a valuable picture or a picture of any value at all.

What is Forestry?

To use a considerable amplification of a definition of Forestry given in the *Gardens Chronicle* in 1875:—

Forestry is the art and practice of growing at the lowest cost, as near as practicable to the place where required, the largest quantity of wood or timber of quality that will reasonably serve the special requirements, upon the smallest area, in the shortest period of time.

To make possible realization of such an ideal, very much is required. Not only is a thorough knowledge of scientific forestry necessary as well as a general knowledge of the art and practice, but also much special knowledge affecting the species of trees best suited to the climatic and other conditions and the needs of the country and also the very fullest local knowledge.

Unfortunately, as has already been indicated, very limited data, especially as affecting Australia and New Zealand, are available, and until proper practices are initiated and have been followed for some considerable time the lack will continue and be of great disadvantage.

Chapter III.

NEED FOR AFFORESTATION, AND THE BENEFITS.

In the past, at least up to comparatively recent times, the limited use of timber and the abundance of natural supplies in most countries, and the ease with which it was obtainable from outside, made it appear to most that afforestation was not a matter of importance or urgency, and that, failing natural sources of supply in any particular country, requirements would easily be met by the planting of any suitable trees almost irrespective of their rate of growth and without calling for any intensive forestry methods. But as time goes on the extraordinary expansion of the uses to which timber and wood products are being put, causing a seemingly ever-increasing ratio of extending consumption and the consequent rapid depletion of natural resources, has aroused the people of most countries to a somewhat fuller realization of the needs for afforestation.

But what has not yet been realized, even by those who have knowledge of the subject, is that the enormously increasing consumption, the rapidly vanishing natural supplies, and *the limitations of the proportion of land that all the most advanced and populous countries can afford to devote to timber production* mean that the production under present methods of afforestation and with slow-growing trees must fall far short of requirements.

That this seemingly obvious great cause contributing to the rapidly approaching timber famine has failed to receive any notice at all, let alone the very prominent notice it calls for, is astounding.

How long, for instance, can a densely populated industrial country like Germany afford to have 26% of her total area in forest?

The sound general principle that production in a country or districts should be confined chiefly to such commodities as it is most fitted to produce at low cost in preference to such as it can produce only at high cost does not apply fully in the case of timber production because of its great bulk and weight compared with value, and also because of the many benefits derivable from afforestation other than timber production, but nevertheless the more extensive forests should be raised in countries and in localities having conditions specially favourable for rapid growth and full utilization of all products, so permitting intensive forestry.

Besides concentration of the most extensive afforestation operations to the most suitable countries and localities, the operations must be carried on, under skilled direction with complete local knowledge, intensively, and with the most rapid growing species of trees which will produce timber reasonably suitable for the requirements, even if necessitating much use of preservatives, in preference to slower growing trees the timber of which is naturally superior.

Benefits of Afforestation and How Best to Attain Them.

The many benefits to be gained by afforestation properly carried out naturally fall under the three headings, Economic, Climatic, and Æsthetic.

Afforestation operations may be carried out with objects coming under one, two, or even all three categories, but generally there will be a main object, such as, for instance, the production of timber, but incidentally benefits beyond those aimed at will accrue, such as protective forests which, while fully filling their purpose, may become important sources of timber supply.

Location.—Though the object or objects in view may often be the decisive factor as to location, such as reclamation of sand dunes, on the other hand upon the location, as a rule, will depend the degree and range of benefit to be derived.

Notwithstanding the very general conception, including that of State and other forest services, *that the proper locations for afforestation operations are areas which, being poor and remote, are of little value*, broadly speaking the nearer the location is to a centre of population the greater and more comprehensive will the benefits be and the greater the profit. Whilst the more remote the location the more limited the benefits and the less profitable the produce.

That such must of necessity be the case will become clear when the benefits derivable from a proper system of afforestation are considered.

Besides the usual primary object—the production of timber for all purposes of construction, wood for poles, sleepers, mine props, fencing, and fuel, and wood for pulping, and for the production of innumerable by-products, all of which may be obtained from remote forests, though if from such necessarily at excessive and possibly prohibitive cost, owing to the heavy haulage costs on a commodity which is of great bulk and weight compared with its value, there are many benefits coming under the category of "Climatic" which can only be gained from forests and plantations being located in many different parts of the country, including closely occupied districts, and there are many other benefits, mostly coming under the category of "Æsthetic" which can only be derived to their full extent from forests and plantations located in close proximity to centres of population—suburban forests—such as those in France, Belgium, and Germany.

Suburban Forests.—In France, for instance, there are some twelve forests, large and small, within ten miles radius of Paris, some fifty within twenty miles, and some eighty within thirty miles.

Remote forests afford timber, wood, and wood products at high cost, but unless planted especially for reclamation or protective purposes they afford very little if any climatic or æsthetic benefits.

Forests and plantations generally distributed throughout the country, each locality having its quota, will (1) produce cheaper commodities, because more intensive forestry and sounder sylvicultural methods can be followed, as most of the products would be near their market, a fuller supply of labour would be available, and a more economical use of it would be possible; (2) the climatic benefits, such as more equable conditions, shelter for the people, stock, and crops, greater humidity, lessening of ill-effects from storms, floods, and droughts, prevention of denudation and erosion, protection of the soil and increasing of its fertility, retarding too rapid dissipation of rain water, etc., and (3) general beautification of the country.

Forests near Centres of Population.—Suburban forests—in addition to affording all the advantages of either remote forests or of forests generally distributed throughout the

country but not suburban, confer many additional benefits, and confer all benefits upon a far greater number. These additional benefits include the providing of healthy pleasure-giving recreative and beautiful conditions, easy of access, and right at the city's gates.

Chapter IV.

CONSUMPTION OF WOOD AND LESSENING SUPPLY.

The immense consumption of wood, but more especially of wood products, and the rapid rate at which natural supplies are being used up are facts so well known that statistics seem unnecessary to support them, and it has to be realized that, though the various estimates may be under or over as to the exact time, we are rapidly approaching, and must in the very near future, reach the very grave situation of there being entirely inadequate supplies available.

The question before the forestry world and others is how to meet the situation, how best to mitigate conditions for the time being, and how most rapidly to turn the tide of shortening to one of increasing supplies, or in other words how best may the excess of consumption and destruction over annual increment be diminished.

The position is a very serious one indeed, and one that can only be dealt with if whole-heartedly tackled by all concerned—trained talent in all branches of forestry, land owners, the general public, Forestry Leagues, Timber Growers' Associations, Millers' Associations, and various governing and legislative bodies.

There is no one royal road to success, and from its very nature appreciable improvement must be slow; therefore, with a crisis so rapidly approaching, action in every direction is urgent.

The various directions in which improvement and reform can be effected are—

1. More economical use of converted material.
2. Lessening of waste in conversion.

3. As far as possible the full utilization of all material large or small, high or low quality, from natural sources of supply and produced by afforestation.
4. The fullest use of preservatives so as to increase durability, and so making practicable the utilization of many timbers now discarded.
5. The prevention or lessening destruction by fires, disease, insects, etc.
6. Better selection of location for afforestation.
7. The planting of more rapid growing species in preference to slower growing.
8. Hastening of growth in earliest stages.
9. Adoption of systems of planting that will insure greatest production.
10. The encouragement of private and local enterprise and competition.
11. Freeing from rates and taxes during non-productive period. Freeing from undue taxation, imposts, restrictions, deterrants, interference, or control.
12. Prevention of State or other monopoly.

CHAPTER V.

THE WORLD'S RESOURCES.

Before proceeding more with the question of remedy, it is well first to shortly review the present timber situation.

According to figures given in the 1926 edition of the *Encyclopædia Britannica*, the total timber resources of the world are contained in some 7,300 million acres, of which 4,800 million are in hardwoods and 2,500 in softwoods. The more important commercial timbers of the world, the softwoods and temperate hardwoods are situated to the extent of 95% and 89% respectively in the Northern Hemisphere.

Very large portions of these forests cannot be considered commercial forests at all, and from much more, even if accessible, the yield would be very small, therefore these or any

such figures are of little value. For instance, Mr. Fraser Story says, in his review of softwood resources of Europe, that only 90 million out of a total of 333 million acres are merchantable.

A better estimate of the present position and future prospects can be gathered by other means. Remembering that approximately 90% of important commercial timbers are in the Northern Hemisphere, and that all the most progressive countries are the greatest consumers of timber and wood products, the approximate position as to supplies in different countries is illuminating.

Finland is the only country in Europe, and together with Siberia, is the only country in the Northern Hemisphere, where the annual increment exceeds the consumption.

It was, until recently, thought that Sweden's annual increment exceeded consumption, but it is now found that the balance is on the wrong side.

Germany, which led the world in scientific forestry activities, and which has over 26% of her total area under scientifically managed forests, is, or was a few years ago, an importer of over 5,000,000 tons annually.

Great Britain is the greatest importer of timber in the world, and her imports exceed 10,000,000 tons annually.

Taking pre-war data, Belgium, France, Italy, Spain, Denmark, Switzerland, Holland, Servia, Portugal, and Greece have to rely on imports. Other European countries, with the one exception of Finland, are, in consumption and export, exceeding their annual increment.

The previously vast forest resources of the United States of America are rapidly vanishing. The forests of the New England, Lake, and South Atlantic States have been all but cut out, and those of the Southern States practically so, and only those of the Pacific States remain, but the drain on those is so great that their exhaustion is only a matter of comparatively a few years.

For some time the United States have had to depend very largely on Canada, and to a lesser extent on Sweden for pulp and pulpwood. They are consuming their timber supplies four times as fast as they are growing. Their per capita consumption of wood is 200 cub. feet against Germany's 37, France's 25, and Great Britain 14.

Canada's vast supplies are being eaten up at such a rate that it is estimated that another twenty-five years will practically extinguish all that can be profitably worked under present methods and conditions.

In Canada waste in conversion is almost equal to the quantity used, and destruction by fire and disease equals one hundred and fifty per cent. of what is used, so that very considerably less than one-third of the total annual depletion is made use of.

It should be borne in mind that far the greater extent—almost all—of the softwoods forests are in the Northern Hemisphere, and also that most of these are north of the 50th parallel, where the conditions are unfavourable to rapid growth even of selected species.

This fact is of great importance seeing that as the ratio of expansion in consumption increases, that of softwood to that of hardwoods increases at a much greater ratio.

At present the average consumption of softwoods is somewhat over 80% to under 20% of hardwoods. Great Britain, the world's greatest importer of timber, imports over nine times as much softwood as hardwood.

As the object of this work is to deal with afforestation in southern climes, it is interesting to note the excessive consumption of softwoods over that of hardwoods, and the very small proportion of present softwood supplies which the Southern Hemisphere has. Whilst softwoods in the Northern Hemisphere are of slow growth, in New Zealand, Africa, and Australia the growth of some softwoods is very rapid, especially so is that of the Pinus radiata (*insignis*) in each of these countries, particularly so in New Zealand, and that of the Redwood (*Sequoia sempervirens*) exceptionally so in the latter country.

The foregoing facts point to the prospect that these countries are sure to become important producers of softwoods. And undoubtedly New Zealand, owing to its exceptionally favourable climatic and other conditions, is destined, if only sound principles and practices are followed, to become the chief forest of the Empire, and timber production should become by far its most important source of wealth.

Chapter VI.

HOW THE SITUATION OF THE WORLD'S SHORTAGE MAY BE MET.

As already a crisis is rapidly approaching, action in every direction possible is urgently necessary, first to mitigate conditions as far as possible, and next towards gradual elimination of the deficiency between production and consumption.

Directions in which reform and improvement may be accomplished have already been indicated, but require some elaboration.

First, much can be done in the more economical use of converted material, and the lessening of waste in conversion.

Waste.—The vast quantities of natural supplies of timber that have, until recently, been available in many countries, and the low stumpage values, undoubtedly led to very careless methods and gross waste and extravagance at every stage. Only the best and largest, if not over large, of only certain species, and of such only those in easily accessible places, being felled, and felled leaving excessively high stumps, and only the best logs taken, all else being left to waste, and generally later to be destroyed by fire.

The proportion of material, actually removed to the mill, to that of the possible amount of useful material that could have been obtained from the forest varies greatly, sometimes being under 10%, possibly even as low as 5%.

Doubtless in many cases fuller use was made, and in recent years, in places, considerable improvement has taken place, but there is still great, very great, waste going on.

The same waste is happening in connection with conversion, but to a very much lesser extent.

Waste in both these directions can be reduced, and should be reduced to the utmost practical minimum.

Next comes what is really part of the foregoing, that fuller use should be made of much that forms the larger proportion of most natural forests, but which is now passed over although the cutting over of the forest almost invariably means its final destruction. There are many trees which, owing to shape or size, are not considered fit for ordinary milling purposes yet could and should be utilized for other purposes such as

rougher timber, case timber, fencing, and fuel, or for the production of wood products. In Sweden, for instance, none, not even the stumps would be wasted. Next there are trees of other species than those usually sought, but which greatly exceed them in number, that could and should be utilized, and to this end full use of preservatives should be made.

Many of these species which are now passed over would provide material for special purposes without use of preservatives, and others for ordinary purposes would do so if treated.

Further, great saving can be made in prolonging the life of ordinary timbers now used, by a fuller use of preservatives.

In neglecting to use such a large proportion of the natural forests it does not seem to be realized that most of these trees have taken many hundreds—some thousands—of years to grow, or that by means of afforestation much expense and thirty, forty, fifty or more years will be needed to grow trees that will produce no better and perhaps much worse timber than the timber of those wasted trees in the natural forest.

The next direction, and one in which enormous destruction takes place is that of useless wasteful clearing.

In Australia and in New Zealand there has been enormous blind senseless waste of valuable timber and of protective forests, and this still continues. Much of such destruction has been in the name of settlement.

Whilst settlement of the country necessitates the clearing of good level lands and even to some extent of poorer lands, sometimes unfortunately ahead of sufficient demand for timber, the forest has been ruthlessly cleared off hundreds of thousands of acres of poor rough lands, some of which showing perhaps at first some degree of fertility as a result of centuries of forest growth and the ash resulting from the clearing fires, were utterly unfit for continual occupation, and which have become mostly not only worthless but a source of destruction. This is still going on, and should be stopped absolutely.

Much of this useless waste and destruction and lasting injury to the country was, in New Zealand anyway, an absolute condition enforced under which only the land could be held. Enormous wealth has thus been destroyed.

Forest Fires.—Forest fires, taking one country with another, have been, and continue to be, far the greater destructive agents. In southern lands Australia continues to be the greatest sufferer. New Zealand has suffered much, though to a lesser proportionate extent, but the most valuable of all, the

kauri forests of the north, have suffered greatly from fire, and still do so from time to time.

A good deal has been done in parts towards protection from fire, but very much more remains to be done. Gross selfish carelessness is undoubtedly the chief cause of fires.

Besides the huge fires that spread destruction over large tracts of country, such as those in Australia, there are the many smaller fires which are for ever levying a toll on blocks or on forest margins and on plantation all of which in the aggregate amount to a great loss. Most of these fires are preventable.

As to the losses due to disease, insects, etc., most of the State Forest Services, some Scientific Institutions and others in South Africa, the various States of the Australian Commonwealth, and New Zealand are active in investigation, etc., but whilst that is most desirable, the most effective means towards prevention of serious ravages from these causes is, as far as Australia and particularly New Zealand are concerned, entirely overlooked, and trouble is being courted by wholesale "pure" planting, and the planting of species in situations unsuitable to them.

Greater Production.—Next to diminishing waste as much as possible comes the question of greater production.

As a matter of course the questions of principles and practices of forestry that are involved in higher production receive full treatment later, but apart from those there is the question of encouragement.

Encouragement to Produce.—Every possible incentive to carry out afforestation by private enterprise and by co-operation, whether public or private, should be given by the State and local authorities, which should also abstain from imposing, or if existing, should remove, conditions likely to act as deterrents.

Where circumstances permit free grants of land of say greater amount than that planted might be made, as was done in New Zealand under the Vogel Act.

Planted lands should be absolutely freed from State taxation and local rates during the period in which they are unproductive.

In New Zealand plantations were exempted from inclusion in valuation of "Improvements," but as most local bodies rate on the "unimproved value" system, under which all "Improvements" are exempted and the total rate required is made up

by a heavier levy on the "Unimproved value," this supposed exemption of plantations is no exemption at all.

All afforestation operations should be kept absolutely free from any interference, control, or any hampering conditions by the State or other authorities.

State control or interference or any conditions tending to weakening of healthy self-reliance and unfettered competition constitutes the greatest blight that can assail any enterprise or business.

Forests should be widely distributed.—As emphasized earlier, afforestation to best serve its purposes and confer its many benefits fully on the greatest number, must be widely distributed in every district and be, to a considerable extent, suburban.

Earlier afforestation or planting, much of it protective and beautifying, was carried out by private enterprise.

This applies to many countries as well as to our southern lands. The very nature of this private planting ensured that so far as they went the results would be fully in accord with the foregoing.

Communal activities have followed in much the same directions, though in a greater degree tending towards suburban afforestation. So both private and communal activities have been all to the good in that they have followed the only course by which the many benefits of afforestation could be derived and most widely utilized and enjoyed.

Private and communal enterprises, but especially private, have been the pioneers, have carried out experiments and demonstrations in all lands and localities, and have so provided the foundations for sound afforestation schemes and the only data available for the establishment of State operations.

On the other hand, notwithstanding these precedents, when State authorities entered the field, practically all their activities were in the direction of afforesation of large areas in more or less remote places. Such locations, being chosen in blind adherence to the fetish of cheap land, thus sacrificed all benefits of afforestation except one—that of timber production—and even that one could be so gained only at unduly high cost and also at the sacrifice of quality.

State afforestation operations, which are subject to the vagaries of political opinion and interference and the exigencies and bureaucratic tendencies of Departmental control and "red

tape," though in some of the southern lands of considerable extent and long standing, are for the most part unproved.

As against South Africa, which has proportionately done most with better results, New Zealand State Forest Service, though in the thirty-third year of its afforestation activities, has failed to attend to the sylvicultural needs of the plantations and has not commenced to pay anything towards proper maintenance, let alone any return on cost. Undoubtedly this failure is due chiefly to wrong location.

Chapter VII.

WHAT GENERAL PRINCIPLES SHOULD GUIDE AFFORESTATION ACTIVITIES.

This opens up a very wide field, and one that should be thoroughly explored before the several answers, for there are several, can be given.

Unfortunately nearly all the larger afforestation operations that have been carried out, or are being carried out in the various countries of the Southern Hemisphere have been initiated and are being carried on with the idea that the same class of operation, with just, in some instances, a variation of species to suit the situation, is suitable for all places and all purposes, quite ignoring the all important question of location.

To be successful, species, system, object, situation, and location must conform with each other.

There are several classes of afforestation based on the main object or on the combined objects aimed at, and the success or otherwise of the venture depends upon attaining the objects satisfactorily and not just upon successful growth of trees.

On the one hand certain trees might contain high grade timber of high class, and yet be absolutely valueless because of their location. But if the object aimed at was not timber but protection they might answer the purpose excellently, but at far too high a cost, as a much quicker growing tree, less costly to grow, might afford a greater protection in half the time at very much less cost.

On the other hand the system of planting adopted may impose a sylvicultural treatment that the location makes im-

possible except at prohibitive cost, and as a consequence the whole may not only fail to be of any benefit whatever but may be destroyed through enforced neglect—which is the case now with considerable afforestation undertakings—whilst the same system practised in a suitable location might be a great financial success, and in addition confer all or most of the benefits of which afforestation is capable.

With these considerations in mind it is well to understand that far the greater amount of the larger afforestation operations which have been conducted under a "rule of thumb" tree planting system are doomed to be economic failures.

The plan followed, blindly adhering to the fetish of cheap land, has been to aim at covering the greatest number of thousands of acres sparsely anyhow, with trees reputed to produce good timber—but which improperly grown may produce very poor timber—in any remote places so long as the land is of little, or practically no value, ignoring from the start all principles of forestry and also ignoring and making impossible any, or anyway adequate, sylvicultural treatment

---

Chapter VIII.

CLASSES OF AFFORESTATION.

Taking the main object, or the main combined objects, as indicating the different classes of afforestation operations they are:—

Timber production.
Protection.
Climatic—including æsthetic effects.
Reclamative.

Timber production.—Whilst in England and Europe competition both of home-grown and imported timber, wood and wood products, has imposed on foresters and all concerned in forestry operations, the task of making their undertakings remunerative at market prices, or having to sell at a loss, in the Southern Hemisphere quite a different position, for some reason, has been assumed, a position based on an uneconomic conception of what is the duty of all good citizens and particularly of the State, and entirely opposed to sound forestry principles.

Just here it is well to give again in the fewest words a definition of forestry, viz.: The art and practice of growing the largest quantity of good timber in the shortest period of time at the lowest cost.

Forestry does not consist in planting trees in remote places, in wide spacing and where sylvicultural treatment is impracticable which can only result in low grade timber, to be placed on the market at excessive cost.

It is economically unsound to produce goods of any kind at an unduly high cost.

The aim, which healthy competition enforces, is production at lowest possible cost. Such is the aim of every good citizen in their own interests, and in that of their fellows, and it should be not only the aim but the imperative duty of the State to see that citizens obtain from the expenditure of the taxpayers' money, the greatest benefits at the lowest cost. And yet in the Southern Hemisphere, where we have supposedly the most democratic and liberal forms of government, private pioneer enterprise has been followed by the entry of the State into what has largely become an absolutely perniciously uneconomic system of afforestation which cannot possibly succeed financially except under a system of monopoly.

That this is recognized by some of those concerned is evidenced by endeavours to obtain control over all afforestation operations; an extent of control that could be used to stifle all competition.

This latter does not apply to all southern countries, but it does, to a very marked degree, apply to New Zealand.

Whilst all monopolies are not necessarily vicious, they possess the power to be so, though mostly kept in check, but State monopolies should be resisted to the utmost, as their power is unlimited and uncontrolled.

Fortunately an extraordinary expansion of afforestation operations, other than State, has recently taken place in New Zealand, and if State control and interference is restricted the result will be most beneficial to the community, as timber growing as an industry in the hands of individuals and companies will have to depend upon its merits in an open competitive market.

As in everything else, so in timber growing, low cost of production must be the dominating condition aimed at, and always bearing this in mind, a more reliable judgment can be formed as to the merits or demerits of any scheme.

It is certainly most extraordinary how politicians and the public in these countries have failed to give some critical thought to the subject, and so have failed to recognize the fallacy inherent in a system under which the aim is to "put up" show records of extent of sparsely planted trees in remote areas, under the assumption that scientific afforestation or any afforestation of value is being carried out.

The production of timber as the main object involves many things. Amongst others the arts and practice of forestry that will ensure high grade quality, but conditions must be selected that will ensure it being done in the shortest time and at the lowest cost.

Timber is a heavy commodity, and of proportionately low value, therefore the handling and haulage costs are most important factors. Whilst this is so as to the main crop it is to a much greater degree so as to all thinnings and small wood.

High grade timber cannot be produced by other means than close planting and repeated thinning. Thinnings, whilst valuable near a market, are for the reasons just given valueless if distant. Consequently the costs of sylvicultural operations in remote forests makes, under present-day conditions, the production of high grade timber in remote places, at a reasonable cost, impossible.

The nearer a centre of population a forest is, the more intensively can the operations be conducted, the higher the grade of the timber and the more cheaply can it and all else from the forest be produced, and the more extensively will all the other benefits of afforestation be afforded and enjoyed.

Protective and Reclamative Forests.—Protective forests, whilst also as a rule being producers of timber and affording many climatic benefits, will almost certainly, from their nature, be located in many parts of the country. Some, close to centres of population, others within closely occupied productive areas, and others in rough country.

Some for the protection of home, stock, pastures, etc., some for water conservation, and some to prevent or lessen erosion, and protect from the effects of floods, and others to reclaim and protect sand areas.

Reclamative forests, for the most part, are very distinct, and their location will obviously be fixed by the particular need. They may be small or of necessity very extensive. Doubtless they will also, in addition to the main object, afford climatic benefits, be considerable sources of timber supply, and

have beautifying effects. They are also likely to be located in many parts of the country, more frequently near centres of population, and near productive lands than in remote places.

Protective and Reclamative forests have for the most part main objects, such as conservation of water supply, prevention of floods, of erosion, of encroachment of water, or of drifting sand, and of affording shelter and protection from climatic severities, but the afforestation of remote poor lands, by which in their unplanted condition no injury is being caused to other lands and from which no climatic disadvantages are being suffered outside their bounds, cannot be classed either as protective or reclamative, and are not warranted unless timber of as good quality, and at as low cost as in nearer locations, can be produced.

The taxpayer or others concerned should not be misled by fallacious claims that the almost certain financial loss incurred in afforesting such areas is compensated for, or lessened by the assumption that they are either protective or reclamative.

It must be clear from the foregoing that the only sure way towards meeting the coming timber famine and to afford the whole community the fullest benefits of afforestation, including forest products at low cost, is to establish forests and plantations in every part of the country where reasonable and practicable, and as near to the market or to water carriage and the people as possible.

To do this the work should be undertaken by land-holders, by private co-operative enterprise, by public local bodies, and by the State, each undertaking, whether State or not, being dependent upon its own merits.

Chapter IX.

PRESENT CONDITIONS AS COMPARED WITH PAST.

Forestry in the present day is faced with a very different situation from that in the past, and in addition forestry in southern lands has very different conditions to deal with from those in the Northern Hemisphere.

In earlier times practically all Europe, including the British Isles, was forest covered. The same applied to a very large portion of the United States, and to greater extent in Canada.

After much destruction of forests in the British Isles some re-afforestation took place, but most of such was for the purpose of the chase and beautification of landed estates.

Practically all such afforestation was carried out with trees belonging to the zone in which hardwoods predominate.

As the demands for timber increased, the consumption resulted in a drain on the natural supplies much in excess of the annual growth, notwithstanding considerable planting, which, as time went on, included species of European pines, and later some American species.

Unfortunately no systematic effort was made in the United Kingdom adequate to check the diminution of local resources. On the other hand continental European countries were more alive to the situation, and general widespread systematic conservation of natural forests and much afforestation took place, with the result that to-day practically the whole of continental Europe is thickly dotted over with forests large and small. Whilst Great Britain has many ornamental woods she has practically no forests to speak of, having somewhat under 4% of her total area in forest. At least that was the position quite recently, but now, fortunately, a new era has been entered upon, and very considerable afforestation is being carried out.

Taking the immediate pre-war figures as fairly approximately indicating the position, it is as follows—as shown by the percentage of the total areas of each under forest:—

	%		%		%
Bosnia-Herzegovinia	50	Hungary ..	28	Rumania ..	18
Sweden ..	48	Germany ..	26	Spain	17
Russia & Finland	40	Norway ..	21	Italy	15
Austria ..	32	Switzerland ..	20	Greece	13
Servia	32	Turkey ..	20	Holland ..	7
Luxemburg ..	30	France ..	18	Denmark ..	6
Bulgaria ..	30	Belgium ..	18	Great Britain ..	4

Many of the forests are natural or based on natural forests, whilst a number are the result of afforestation, but most, whether wholly natural, partly so, or planted, have for long been worked under more or less definite plans tending towards continuity of supply, and so, no matter how slow growing are the various species of which they consist, there is in every year a quota which becomes available for immediate use, but, so far as the most industrially advanced countries are concerned, this quota is entirely inadequate, and their requirements have to be made up by imported supplies.

The United States and Canada, with their originally vast forest areas, for long seemed to stand as inexhaustible sources from which European and other shortages could be made up, but ruthless waste and other causes of destruction have so added to the continuous drain by lumbering that these supplies, for the protection or continuity of which practically no steps, or at least no adequate steps, are being taken, are rapidly vanishing, and the United States, though exporting from the West Coast, is already drawing heavily on Canada and even from Sweden for softwood supplies.

Earlier demands on forests were almost entirely for timber for direct use in construction of all sorts, for poles, mining timbers, railway ties, and for fuel. The total of these needs was small—very small indeed considering the vast natural supplies—and further the demand was very largely on hardwoods of extremely slow growth, and the natural durability of these timbers had to be depended upon unaided by the use of preservatives.

With industrial development and the concurrent exceedingly rapid increased consumption of wood and wood products and with it the still greater proportionate increase in the use of softwood, quite a new and exceedingly critical position has arisen, which is, that with the enormously increasing consumption of timber industrial countries of the Northern Hemisphere, with their density of population, cannot afford such large proportions of their areas to be under forest as would be necessary to meet their demands, under the present system of forestry, with the slow growth that takes place in the Northern Hemisphere.

To gauge fairly how sure this position is, it is only necessary to take the case of Germany as displayed in the immediate pre-war figures, and when considering them to bear in mind that the greater the progress the greater is the proportionate consumption of wood and wood products, and that the extending consumption steadily progresses at an increasing ratio.

Germany led the world in scientific forestry. She had 26% —equal to ·6 acres per head of population—of her entire area under forest systematically managed, and yet she imported 4,600,000 tons, equal to about two thousand million sup. feet of timber per annum.

Towards remedying such conditions better methods will have to be adopted, more rapid growing species planted even at some sacrifice of quality, free use of preservatives being

made when durability is required, and concentration on timber production in countries and situations having the most favourable conditions for rapid growth and heavy production.

Turning from the northern lands to those of the south, there is no doubt whatever that some of our southern lands with their exceedingly favourable conditions for tree growth and the enormously rapid growth of some important species in these climes, have the opportunity of becoming the greatest timber producing countries, and with their sparser population, they hold out the only real hope in the direction of lessening, if not in time making good, the shortage.

Above all others, New Zealand, with its narrow insular form, many harbours, and short land carriage, and its exceptionally favourable climatic and soil conditions, cannot, unless hampered by out-of-date and "rule of thumb" methods, and harassing conditions, fail to become far the most important timber grower of all.

Chapter X.

AFFORESTATION, WHERE AND HOW TO SET ABOUT IT.

Afforestation should be carried out in every district, but to the greater extent in localities most suitable, and as much as possible in places of easy access, near centres of population, near harbours or waterways, and not in remote places where intensive forestry cannot be practised, and from where haulage will be costly.

Further it must be carried out intensively, under proper skilled guidance, with thorough local knowledge, under systems that will ensure the most rapid, healthy growth, reduce disease and fire risks to the utmost, and ensure the production of strong, high grade timber at low cost.

The foregoing involves the following:—Proper selection of locality and situation, local knowledge, lay-out so as to facilitate exploitation to the utmost, careful selection of seed, grading of seedlings, careful planting, planting of such species as complete local knowledge gives assurance of being most suited to the locality, dense planting in mixture, and proper attention throughout, including repeated thinning.

It would be quite superfluous to mention the foregoing but for the very common conception that forestry begins and ends with the planting of trees. A complete ignoring of disease and other risks, the maintenance of fertility of the soil, the rate of growth, the quality of the timber, the amount of the yield, need for suiting the market, or in fact everything upon which economic and financial success depends.

Most of the works on Forestry deal with general principles of Forestry, and proceed with directions as to practice applicable in the particular country, and then with extensive descriptions and details about many species of trees which for that country are considered more or less suitable for timber production, giving information as to mixtures, thinning, pruning, and such like, but very little information, if any at all, as to rate of growth.

Particularly there is an entire lack of any information whatever as to comparative rates of growth or other results when various species are grown under various different systems and conditions.

It would appear that for some unexplained reason data have not been collected upon which information on this very important subject could be based.

For the rest Forestry works are mostly taken up with diseases and pests which affect the species of trees dealt with, and with tables of various sorts, etc.

It is the intention in this work to avoid as far as possible any unnecessary repetition of what is fully dealt with in so many valuable general works on Forestry, and to avoid attempting the impossible of covering the whole field in one small work. Such subjects as "Diseases and Pests," "Lumbering," "Preserving," etc., are and should be subjects for separate and special publications.

The desire here is to deal with the general principles, arts, and practices by which afforestation can be most successfully accomplished in our southern lands so as to produce the largest quantity of good grade timber, quickly and at low cost, and at the same time make the many benefits which may result from afforestation as fully and widely effective as possible.

It would be desirable to proceed in definite order dealing with each step by itself, as it should be dealt with in practice, but such is impossible because so many are interwoven and interdependent that even right at the start neither clarity nor completeness can be gained without either the assumption of

full knowledge of matters to be dealt with later or then of very lengthy digression. A middle course involving a degree of repetition seems the only way open.

Chapter XI.

CLASS AND GRADE OF TIMBER.

Leaving out of consideration for the time being wood for manufacture of wood-products, the aim in afforestation, next to rapid production at low cost, should be the growing of high grade timber of whatever class—whether of the more highly prized or less valued classes—it should be the highest grade of its class that can be economically grown.

High grade timber of all classes always commands much higher prices and readier sale than lower grades, and in the future will command still proportionately higher prices and readier sale, as the natural supplies that have taken many hundreds or even thousands of years to grow, become exhausted.

High grade timber belonging to an inferior class of timber can be used, and will have to be used for many purposes in place of high class timber.

Long, even, dense-grained timber, free from knots, shakes, and other blemishes, though belonging to a poorer class of timber, is superior for most purposes to faulty low grade timber belonging to a higher class.

Obviously grading varies somewhat in different countries, and also according to the particular class. For instance, timber for beams comes into quite a different category from that for cabinetmaking, but generally speaking first grade timber is that which throughout is free from sap, is long, straight, even and dense grained, and is free from knots, shakes, gum, or other veins, timber which has grown vigorously to full height with little taper or twist, whilst making steady but slow diameter growth, and so having annual rings of practically even thickness throughout, and for its class, close together; timber from trees that shed their side branches before any part of them had been embedded in the wood.

A 12-inch plank of "low grade" timber or "rubbish" showing $1\frac{1}{2}$ annual rings to the inch, equal to an excessive diameter growth of 12 inches in 9 years. The timber is weak, soft, coarse grained, full of "loose" or "cork" knots, the result of "over open" planting.

From first grade timber through the various grades as the degrees of faults increase till the lowest grade is reached, which consists of timbers which have some one or more faults in excess or a combination of faults—sappy, coarse, uneven grained, knots, shakes, veins, etc.—material which is little more than fit for fuel, if fuel it will make, or then is rubbish.

Except for the purpose of some wood products, for which it must be produced at very low cost, lowest grade timber is not worth growing.

Forests planted and managed throughout under the best principles and highest skill will always produce quite sufficient of lower grade timbers to that of the best to supply fully the proportionate demands of the market, without any at all, let alone a great many, very extensive forests being grown under a system that cannot do other than result in far the greater proportion of the produce being low grade.

How to produce high grade timber.—Dense planting and repeated thinning are fundamentals of the science and practice of forestry. On proper location, selection of seed and species, and on following these principles with knowledge and skill, will depend the attainment of successful growth, heavy yield, high grade timber, early and repeated returns, a proper building up of the forest floor, maintenance of fertility of the soil, and financial success.

Although some trees, among which are some species of Eucalypts, are not so greatly affected generally speaking, it is impossible to produce high grade timber except by adhering to these principles.

It has been expressed tersely as follows:—If you want to produce good timber plant densely, if you plant loosely you will produce rubbish.

But dense planting entails as a necessary consequence repeated thinning.

That open or loose planting results in rubbish is only slight exaggeration, for taking pine timber for example, for to the pines we must look for the greater portion of the timber that will be required, open planting causes reduced height, growth, and excessive branch and diameter growth and much taper, resulting in weak, coarse open-grained timber, studded with knots, and in the case of rapid growing trees the timber right through will be pierced more or less with cork or loose knots,

the dead branches not having had time to rot off before being embedded in the timber.

If open planting is followed by neglect to thin, undue retarding of growth will take place later, followed by much natural suppression, inviting disease, and the dominating trees—a small proportion of the original number—will be heavily and excessively branched, and will not only yield low grade timber but the total yield will be very much less in quantity than if the forest had been properly cared for.

On the other hand close planting quickly covers the forest floor and excludes the light, and so all side branches are early eliminated, rapid vertical growth with minimum taper takes place, while diameter growth is retarded, giving time for the side branches to drop off before injury is done to the wood.

The question of the great importance of retarding—though not unduly—diameter growth during the period of most rapid vertical growth has not received the degree of recognition in works on forestry that it is entitled to, and in our southern lands it seems to have been quite ignored. Very generally there is held a conception that rapid growth renders close planting unnecessary. This latter is a very serious or, it may be said, fatal error. The more rapid the growth the greater the side branches and the more quickly and deeply are they embedded by the rapidly expanded diameter growth. By the resulting knots and over-wide annual rings of weak open-grained timber the product is reduced to low grade, which no later treatment can remedy.

By the exercise of what is the chief art in forestry, judgment in thinning at the right time and to the right degree, even healthy growth is maintained throughout. The result is that which is most desired and which can only be attained by adherence to these principles and practices—long, even, dense-grained, clean, strong timber, free from knots or other blemishes. The total yield will be the maximum and of the highest grade, and such timber will always command ready sale and the highest prices.

Note.—High grade timber finds ready sale in New Zealand at from £2 to £3 per 100 sup. feet, whilst low grade is a drug in the market at £1 per 100 sup. feet.

Chapter XII.

SPACING OR DENSITY OF PLANTING.

As has already been stated, dense or close planting and repeated thinning are fundamentals of forestry and proper methods of sylviculture, and the successful carrying out of these two vital parts of the practice of his profession calls for the highest art and skill of the forester.

Nothing but sound and matured judgment gained by experience will equip him with ability to apply the principles in practice to the fullest advantage.

It is readily understood that there can be no absolute rules, for with every variation of circumstances and conditions—location, market, climate, soil, species, "pure" or "mixed" planting, and so on—all of which have to be taken into consideration, and whilst adhering to the principles, their application and the consequent concurrent operations have to be modified, in degree, as the circumstances and conditions require.

Whilst long ago open planting was in vogue the practice altered, until what amounted to over density became the rule, since when some change has taken place in the direction of less density, but no authority on Forestry upholds or does anything but condemn, directly or impliedly, over open spacing, and all contend for sufficient density to ensure proper growth for the production of good timber.

No one who has had a sufficient experience to form a sound judgment or who has for a lengthened period of years made close observation of the growth of timber under varying conditions, or who has made careful examination of timbers which have been grown under various conditions, full particulars of which are known to him, can do other than condemn open planting.

Sir David Hutchen, who had world-wide knowledge, and who, after being long associated with South African afforestation operations, which are the most successful and extensive in southern lands, reported very fully on Australian forests and afforestation, and later spent some years in New Zealand, whole-heartedly condemned "open" planting.

The following are some extracts from his *Australian Forestry*, 1926:—

Page 124—"In both Victoria and South Australia it (Insignis pine) is a sparsely grown coarse-timbered pine that has been raised in cheap sparse plantation, and the timbers have been used for little but packing cases.

. . . . This is quite rough timber from trees grown as far apart as 8 feet to 16 feet."

Page 131—"It is certain that Australia has erred in always putting in very low grade open planting. It is mainly this that has given Insignis pine its reputation as a coarse timber in Australia."

Writing again of the Insignis:—

Page 257—"It has grown from 30 to 50% faster than any other pine planted in Australia. It has been grown always in sparse plantations, and has produced consequently a second-class timber."

When speaking at the Annual Meeting of the New Zealand Forestry League in 1918, Sir David said:—

"The good feature of the Government timber plantations is the adoption of high-class dense planting."

This referred to all the earlier planting, which was mostly spaced 4 ft. x 4 ft., equal to 2,720 trees per acre. This spacing, whilst open to slight modification, was unfortunately entirely superseded by the much-condemned excessively open spacing of 8 ft. x 8 ft., equal to 680 trees per acre—just one quarter the number of the "high-class dense spacing" commended by Sir David.

A much earlier visitor to New Zealand was an India Forester, Captain Campbell Walker. In a paper on Forestry written in New Zealand he says:—

" . . . but we *cannot* rear good timber if planted out far apart. It is much better to have them rather too thick at first. . . ."

Turning to Professor C. E. Curtis, in his *Management and Planting of British Woodlands*, we find the following:—

Page 9—"The first principle of forestry should be brought to bear on the future, viz., that of growing to full maturity the largest quantity of timber per acre that it is possible to grow. This can only be achieved by *maintaining a full plant from the earliest years.*"

To gather what, in his opinion, constitutes a full plant we can turn to page 31—

"Opinions differ as to the most suitable distance between plants, but 3 feet planting is now seldom adopted as being only

suitable to pole plantations. It is, in the first place, an extravagant method, costing at least one-third more than 4 feet planting, the future of the plantation will suffer through too close contact in early stages of growth. In my practice—and I have had time to prove its efficacy—I plant 4 feet apart, and on the equilateral principle."

It is well to note that 3 feet, equal to 4,850 trees per acre, is considered too close except for poles, and that experience approves of planting 4 feet apart, equalling 2,720 trees per acre as good, and which distance Sir David Hutchen termed for New Zealand "high-class dense planting."

A further knowledge of Professor Curtis's opinion as late as 1919 can be obtained by reference to his *Practical Forestry*:—

Page 59—"To come to a conclusion, however, which may serve as a guide to the young forester, we may take, when planting conifers alone for timber purposes, a distance of *not less than 4 feet and not more than 5 feet.* When planting for hop-poles $2\frac{1}{2}$ to 3 feet, and for pit-props 3 to $3\frac{1}{2}$ feet. If our object is rearing of hardwoods, the distance may range from 12 to 20 feet, in which case we should *make up with conifers 4 feet apart.*"

Moon and Brown, in their work *Elements of Forestry*, 1915, gives the following:—

Page 120—"Spacing and Costs.—The ordinary spacing for open planting is 6 feet x 6 feet. . . . . Where trees are planted for short rotation . . . closer spacing may be made. In Germany, where planting material is cheap and land valuable, foresters plant intensively, sometimes up to 5,000 seedlings per acre." (This equals about 3 feet x 3 feet spacing.)

In the above 6 feet x 6 feet is termed *open planting.* Ferguson, in his *Farm Forestry*, 1916, has the following on the subject of effect on timber:—

Page 40—"Owing to the long, clean trunks that have resulted from the rapid height growth and the shade caused by the trees growing closely together, the diameter growth put on annually during this stage is of clear wood, and the trees increase rapidly in value for timber."

The important point made here is that owing to density of growth the trees have attained height and the branches have been eliminated before appreciable diameter growth is made, and therefore the timber afterwards will be clear of knots—clean, long, and straight.

TABLE I.

TABLE OF NUMBERS OF TREES PER ACRE AT VARIOUS SPACINGS IN FEET.

Distances Between Rows	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DISTANCES Between Trees														
3	**4840**	3630	2900	**2420**	..	..	..	..	..	..	..	..	..	..
4	3630	**2722**	2178	1814	1555	**1360**	..	..	..	..	..	..	..	..
5	2900	2178	**1742**	1452	1244	1089	968	**871**	..	..	..	..	..	..
6	2420	1814	1452	**1210**	1037	907	806	726	660	**605**	..	..	..	..
7	2074	1555	1244	1037	**889**	778	691	622	565	518	478	**444**	..	..
8	1814	1360	1089	907	778	**680**	605	544	495	456	418	389	363	**340**
9	1613	1210	968	806	691	605	**537**	484	440	403	372	345	322	302
10	1452	1089	871	726	622	544	484	**435**	396	363	335	311	290	272
11	1320	990	792	660	565	495	440	396	**360**	330	304	282	264	246
12	1210	907	726	605	518	453	403	363	330	**302**	272	259	242	227
13	1117	837	670	558	478	418	372	335	304	279	**257**	239	218	209
14	1037	778	622	518	444	389	345	311	282	259	239	**222**	207	194
15	968	726	567	484	414	363	322	290	264	242	218	207	**194**	181
16	907	680	544	454	389	340	302	272	246	227	209	191	181	**170**

Number of trees per acre if planted on the "Square" is shown on the diagonal line in Black Type.

,, ,, ,, "Alternate Double Spacing" system appear in Black Type as last numbers on the first to sixth lines.

Maw, in *The Practice of Forestry*, 1909, deals with the subject of density in the following manner:—

Page 97. "The extra expense of planting the large number of seedling trees is not very great; and it is always most essential to obtain a close canopy as soon as possible; and the necessity for filling up the blanks is largely avoided. The actual distance apart at which trees should be planted depends chiefly upon the persistency of the side branches and the vigour of each year's growth. The side branches must be naturally killed before they are too big to readily drop off; in other words the trees must be planted so close that large side branches can never develop."

He then goes on to give the distances at which to plant many different species, which is given for the greater number as from 3 to 4 feet.—4,850 to 2,720 trees per acre.

A most important point is included in the foregoing, which is to the effect that the side branches must be eliminated before they become large, or in other words before they form any heart, and whilst they are just *sapwood that will rot right off without any part becoming embedded* in the later diameter growth. Only close planting will ensure this.

The terms "dense" and "open," "over dense" and "over open" being only relative and as obviously as the degree of density will vary with the nature of the plantation, whether "pure" or "mixed," also with the species and with the situation, absolute definiteness can not be laid down, but spacing ranging, according to species and circumstance, from 4 feet to 5 feet may be taken as a fair mean approved spacing, and subject to exceptions in special circumstances, under 4 feet apart as "over dense," 6 feet as "open," and over 6 feet as "over open."

It has to be remembered that this question of spacing distance has always been and still is a very vexed one. This is not at all surprising, for the degree of denseness or openness varies with every species, in "pure" planting or quality of mixture, with climatic and soil conditions, with locality and with the market, and whilst all authorities support "dense" but not "over dense" planting, as opposed to "open" or "over open," many who are interested in forestry, and many who have had considerable connection with afforestation operations contend that "dense planting" incurs penalties that are not incurred by "open" planting. Penalties such as over thin stems, congestion of roots, insecure holding, retarded growth,

and also failure to secure one of the chief benefits claimed for "dense" planting, viz., elimination of side branches, as they aver that thinning will permit their growth later.

On careful analysis of their contentions it will be found that these opinions have been based either on experience in connection with some one or two species requiring exceptional sylvicultural treatment or which may have been subjected to special soil or other conditions, or, in other words, the opinions have been formed with lack of sufficiently wide knowledge.

An article under the heading "Planting Distances," which was a reprint of an Editorial in the July, 1927, issue of the *Quarterly Journal of Forestry*, appeared in the October issue of the *Australian Forestry Journal*. It is an exceedingly interesting article from the fact that the foregoing suggestion as to the incompleteness of information on which opinions are formed is exemplified. Among other things two examples are given in connection with Douglas fir (Oregon pine). One of an area planted at 4 ft. x 4 ft. = 2,720 trees per acre evidently, judging from what happened, planted in unsuitable soil, and also the thinning of which was neglected. The other, planted 8 ft. x 8 ft. = 680 trees per acre, which is described at 23 years of age as "looking most promising," but nothing is said about what the grade of timber would be or anything about the Douglas fir, in any case, requiring special sylvicultural conditions. Later on, a case is given showing where the planting of Douglas fir at 3 ft. x 2 ft. spacing (extremely dense) suited certain conditions and proved a financial success.

The concluding paragraphs of the article are enlightening. They are as follows:—

"It is clear, however, that there must be a limit to the distance between trees. In the discussion following Sir Hugh Shaw Stewart's address, Mr. Robinson remarked 'My own tendency is to get wider and wider in my planting distances, and the only reason I do not get really wide is because I have not the courage.'"

"It would be interesting to know what Mr. Robinson really means by 'really wide.' For myself, I regard the 8 ft. adopted by Sir H. Hoare for Douglas fir as being beyond my courage, whereas 6 ft. might be adopted as a normal practice for this tree. I should like 6 ft. for Corsican pine, too, if I could be certain that the early branch pruning would be carried out. This tree suffers from overcrowding, and its young thinnings are of little use, but knots are a serious fault in Corsican timber.

For Scots pine, on the other hand, 5 ft. would be generally considered very wide planting, and for larch there is little reason to plant wider than 4½ feet, as the earlier thinnings can generally be marketed."

There are some species from which side branches cannot, by natural means for suppression, be entirely eliminated, and a degree of pruning may have to be resorted to. There are some other species the branches of which are persistent in "pure stand," and with many species close planting in "mixed stand" is more effective than in "pure stand."

Some of the species, the side branches of which persist, taken somewhat in the order of persistency, are:—Larch, Spruce, Douglas fir (Oregon), Corsican pine, and Redwood. All such species require special conditions and special sylvicultural treatment.

It has to be remembered that undue retention of *dead* side branches and not of the *living* ones is the cause of by far the greater and really serious injury to the timber. This is especially the case with fast growing species.

In some cases continuance of green side branches may enhance the value of the timber, but in every case without exception any undue retention of dead branches causes the worst possible faults in the timber for practically every purpose, and in addition creates serious disease and fire risks.

The suggestions that density—not over density—will cause undue thinness of stems, and that the aim at elimination of side branches will be defeated by branching that will take place later as a consequence of thinning, are quite fallacious unless thinning is unduly delayed in the first case or is carried out too soon and far too heavily in the latter case.

Dense planting induces rapid height growth and the production of long, clean, straight stems from which very few and only slender side branches are produced and these are quickly eliminated. The trees during these early years reach the major portion of their final height growth and around these clean stems which according to situation and species would be 50, 60, 80 feet or more in length, clear of any branches, each year as thinning is carried out, grows clean, strong, knotless, straight-grained timber. Even as thinning takes place and assists further height growth, the earlier rapid vertical growth due to density would continue to lessen any tendency towards growth of side branches.

A B C

HIGH GRADE TIMBER.

A.—A 12-inch plank showing clean, even grown, straight grained timber. Owing to a period of too rapid diameter growth—12 inches in 12 years—the result of rather "open" planting, the timber lacks density and strength.

B.—An 8-inch plank of properly grown timber, showing a growth of eight inches in twelve years. The timber is clean, straight grained, even grown, dense, and strong, the result of proper close planting followed by judicious thinning.

C.—A plank of the timber mentioned in "B" cut off the "back."

Such trees produce long length, clean, knot-free, strong, high grade timber, with minimum waste in conversion, and of whatever class commanding ready sale at highest market values.

Whilst short length, weak timber, with "cork" or "loose" knots and many blemishes, the product of trees grown from "over open" spacing which allowed large side branches with heart wood to grow before being suppressed, would, after excessive waste in conversion, find, as low grade timber, slow sale even at lowest prices.

Further, the yield from close planted and properly thinned stands is much greater than that from loose planted and less thinned.

By actual experience it has been shown that Pinus insignis planted at 6 feet spacing and systematically thinned grew 40% more timber in the same time than that planted at 9 feet spacing also thinned.

By some it is held that the closer the spacing the greater will be the proportion of natural suppressions. Very possibly this may be true of some species if planted "over densely" especially where the plants have been unequal in quality, but with most species where the plantations have been well established with even quality and type of plants well planted and cared for, and thinned from time to time, the percentage of natural suppression will be in the reverse order, viz., less percentage loss in "dense" than in "open" plantation.

However, there will always be some faulty trees and some that are naturally suppressed whether a plantation is more or less "dense" or more or less "open," and it must always be borne in mind that only by close planting can close fine-grained strong timber be grown.

In the case of Eucalypts, for instance, more "open" spacing will give more rapid development and less natural suppression in early years, but the timber of Eucalypts is used almost entirely for purposes where strength is required, such as for poles, piles, stringers, etc. If grown in "open stand" in New Zealand, for instance, they put on diameter growth at such a rate that the timber is really unfit for the purposes for which it is required. Trees so grown of the dimensions required would seriously lack strength and durability, and if let grow until they were strong enough would far exceed usable size.

Eucalypts must be grown, especially in New Zealand where the growth is so rapid, so densely as to retard greatly diameter growth whilst height growth is attained, even at the expense

of a high percentage of natural suppression, for only by this means can strength be ensured.

In connection with Eucalypts it is necessary to point out what has not so far been given the attention that it should, and that is the very important effect that the degree of moisture has on the growth and on the quality of timber of Eucalypts.

Where the rainfall is low and the soil and atmospheric moisture is deficient the rate of growth, and in many cases the quality of the timber, suffers greatly and dense planting will result in very heavy natural suppression or a very large percentage of weak spindly rods.

The position is quite different where there is ample moisture available. Much denser planting can be—in fact should be—practised, and in many cases the quality of the timber grown is superior to that of trees grown where moisture is deficient.

It is contended by some, even by some who are supposed to know, that fast growth justifies wide spacing—open planting—on the assumption that, for instance in the case of Insignis pine, the rapid growth ensures a much quicker closing of the canopy and consequent *killing* of the side branches. This latter is true, but it is *elimination* not just *killing* that is necessary. Rapid growth, if anything, is a reason for denser planting. Rapid growth with "open" planting means besides rapid height growth, rapid growth of heavy side branches and of diameter. The closing in of the canopy later will kill the lower branches, but the existence of a mass of heavy branches, due to earlier openness, will promote continued rapid diameter growth. This heavy diameter growth quickly surrounds and embeds the dead side branches before they have time to rot off. The same will happen with the higher whorls of branches, and consequently all the timber will be seriously lowered in grade.

Besides the bad effect on the quality of the timber, "open" planting, consequent on the growth of heavy branches, adds greatly to the cost of logging, and also to that of conversion.

Chapter XIII.

THINNING.

Thinning is the most important part by far of the forester's work, and by the way it is carried out his skill and judgment will be put to the greatest test.

If the forest has been established on sound lines—species well chosen considering the situation and the class of planting, and above all the spacing has been well judged—the forester's task will not be so serious, but if the forest has been established on unsound lines the task will at the best be exceedingly difficult, and the result may amount to no more than a lessening of the evils, for errors in forestry cannot be made good. No forester, however skilled, can rectify the faults due to faulty establishment or past bad management.

The forester's aim must always be to produce in the shortest time the largest quantity of high grade timber at the lowest cost. To do this he, having selected the best situation for favourable growth, will choose such species and plant them in such density, either in "pure stand" or "mixed stand" as will be most favourable and will give a proper foundation upon which to further practise his art and skill in sylviculture.

That nature goes about her business regardless of time and cost and proportionate result we know, but we know little of how slowly or of the earlier stages.

We can tell the ages of the trees we find standing in the forest—for instance of those composing a fine almost pure stand of timber—but we can tell little of the building up of the forest, of which these trees are only the present representatives of unknown generations.

Some stands, though containing trees some with thick and others with thin boles, may be all fairly even aged, on the other hand it may consist of trees of all ages, the older being the parent trees of the younger.

Usually in the case of mixed ages the trees will vary greatly in height and the timber in quality, and also the yield of timber will be low, whilst the yield of the even-aged stand will be high and mostly long length clean high grade timber.

An uneven-aged stand is usually the result and continuance of a very sparsely stocked forest, whilst an even-aged stand is without doubt the result of simultaneous new growth after all the smaller growth anyway of the forest, leaving nothing but some of the greater trees, over the whole area or large portions of it, had been killed by some destructive agency, such as fires.

The new forest probably started life with a dense growth of all kinds, mostly consisting of lesser sized and shorter lived species, which act as nurses to the growing saplings from which the timber stand has sprung. The lesser and shorter-

lived growth would gradually succumb, but not before it had caused the young timber trees to grow long straight clean boles to the greater part of their full height.

If still dense, as probably they would be, a proportion of these would in time be naturally suppressed, but the stand would be fully stocked with long boles, which would ultimately give a heavy yield of highest grade timber, but this would be accomplished at a very great expenditure of time, for throughout, after the earliest stage, the continued competition in unrelieved density would greatly retard growth, taking many hundreds of years to accomplish what less than one hundred perhaps could have done.

The results of such operations of nature unaided afford a very interesting study, and with careful examination of the two stands, even aged and uneven aged and of the timber cut from each, some basis to work upon can be established, and would prove most valuable to the forester as indicating the direction in which his skill would have the greatest effect.

It is for the forester, whilst adhering to the principles in the establishing of his forest that will ensure the production of high grade timber, to prevent the waste in time that takes place under nature's methods of survival of the strongest after an exceedingly prolonged struggle.

He should see, whilst aiming at the young trees making the most rapid height growth with a minimum growth of side branches and their rapid elimination, that health and vigour is maintained, no undue check of growth being caused by overcrowding either above or below ground—of the trees or of their roots.

Before such occurs he should make his first thinning, but should on no account overdo it. Over severe thinning is worse, much worse, than under thinning. Better that a slight retarding of diameter growth should take place than that the forest floor be opened too much.

Over opening of the forest canopy subjects the trees to injury by sudden excessive exposure, which after the check is got over will be followed by extra growth of side branches, failure to kill them off quickly and also causing undue increase in diameter growth. Injury is also caused to the forest floor by excessive exposure.

Further, with some species and some soil formations there would be a great risk of uprooting by storms of many individual trees or masses of trees.

As we are dealing with afforestation in southern lands where, though great numbers will thrive, the number of species desirable to plant is distinctly limited, and the hardwood planting will almost entirely be confined to Eucalypts and a few Acacias, and the softwoods to such as Insignis, Redwood, Oregon, and a few others, we have not nearly the number of varying conditions to deal with nor the need of excessively dense planting—that is planting at a density exceeding that obtained by 4 feet spacing.

Some writers on forestry deal with the subject of thinning from a stand that the main object in thinning is the fostering of the most valuable species if a "mixed stand" and of the dominant trees of a "pure stand."

Whilst this is certainly a permissible, though restricted view to take as a system to follow for the improvement of natural forests, long neglected plantations, some mixed stands, and to an extent uneven aged stands, generally speaking it is not applicable to "pure stands" or even to many "mixed stands."

It is also held by some that by this system the heaviest yield can be obtained, but even if such is the case in some instances—it certainly is not always so—the question of grade is overlooked. Trees long grown in the shade, and not those which have forged ahead of their fellows, produce the finer grained timber.

Where possible, whether "pure" or "mixed," all planting should be systematic and of regular spacing.

If a systematic regular "mixed stand" then all but the species of which the final crop is to consist will really be in the nature of nurses, and will be removed as thinnings.

If, and it is likely so, the number of those which are of the species of which the final crop will consist have to be reduced, the removals should be made so as to leave the balance as equally spaced as possible.

In the case of "pure stand" each thinning should be made so as to, as far as possible, leave the remainder equally spaced —thinning by alternate lines in one direction or other, which would mean alternate trees if the spacing has been, as it should be, on the equilateral system. Attention should be given from the first to check the growth of forward plants by cutting back and pruning, and foster at the same time that of backward ones by giving them plenty of room.

Under such a system of planting and thinning a sufficiently even height stand can be maintained throughout, and a very much better grade and much higher yield will be obtained than by any system of selective thinning.

In all cases whether "pure stand" or "mixed stand," and whether the spacing is "dense" or "open" or "over open," thinning must be repeated from time to time throughout the greater period of the forest's growth, as many times, and at such intervals, as the situation, the species of trees, and the rate of growth cause a tendency towards congestion.

While undue overcrowding must be prevented, a density should be maintained that will throw more energy into height growth than into diameter growth, until height growth is completed. By this means an unbroken canopy will be maintained, and so sparseness and weakness of side branches and their early elimination will be effected, and at the same time the forest floor will be built up.

A forest so maintained will ensure healthy vigorous growth, resistance of disease, high grade and heavy yield of timber, and will incur a minimum risk of damage by fire.

Some whose knowledge of the science and practice of forestry is limited, and who conceive that successful growth of trees over large areas constitute forestry, practise wide spacing, chiefly it would appear from an idea that wide spacing, such as 8 feet by 8 feet obviates the need for thinning. Such an idea is absolutely fallacious, and the practice can lead to nothing but disappointment.

The wide spacing will permit the growth of strong side branches, which will form heartwood before they are killed, and the rapid diameter growth induced by the excessive room will embed the side branches before they rot off, and so destroy the quality of the timber. This is later followed, say about the twelfth year, by overcrowding unless thinning is carried out. Two thinnings at least will be required, three would be better, possibly more.

The adoption of the practice of wide spacing was in earlier cases brought about (later to be followed by others under the impression that it was in accordance with approved practice) by an endeavour to escape from the inevitable economic and financial failure of afforestation, for timber purposes, in remote places where thinning instead of being a source of considerable profit, became an unbearably heavy charge upon the forest.

Not only does wide spacing make impossible the production of anything but low grade timber, which, being produced in great quantities in proportion to the amount of higher grade, will be almost valueless, especially if subject to long, heavy haulage costs, but the wide spacing only in a measure lessens the amount of thinning that should be done.

As compared with denser planting the first and possibly the second earlier thinning may be escaped, but none of the others. As has been pointed out, thinning has to take place from time to time throughout all but the later period of the forest's life.

The final crop only represents, according to the species and the class of material it is desired to produce, from about one-eighth to say one-sixteenth, or even as little as a fortieth, of the number originally planted, except in the case of "over open" planting, when the final crop may represent as much as one-fifth.

If Insignis, for instance, is planted at a spacing of 8 x 8 feet, thinning must be carried out some time between the tenth and fourteenth year, according to the rate of growth. Owing to over open planting these thinnings would be weighty and branchy, and have much taper, and would have to be removed from the forest at no matter how heavy cost, but would be valueless in remote places for timber purposes, and of very little value, if any, anywhere else unless the location of the forest was especially favourable. A second thinning at least would have to be made, but owing to low grade and not large size would not be profitable for milling purposes in remote, or certainly not in very remote, places. A third thinning should produce material of value.

If these thinnings were not carried out—say in the case of Insignis spaced 8 feet—after the tenth to fourteenth year over-crowding of both crowns and roots would take place and be followed by greatly retarded growth, resulting in injury and natural suppression of a considerable percentage of the trees, and a reduction in the total yield by 40% to 60% of what might have been obtained by close planting followed by proper thinning. The overcrowded conditions would also much increase liability to attacks by disease and insects.

A forest so established and left to grow without thinning, whilst being worse than the natural forest because of lack of early density, suffers under the very conditions of prolonged struggle and much greater expenditure in time than the natural forest does, and which it is the business of the forester

to use his art and skill in preventing. In other words, no such afforestation and neglect can be termed scientific forestry.

To repeat, to produce a heavy yield of high grade timber in the shortest time, planting must be dense and must be followed by frequent thinning for the greater period of the forest's life, very ample room being given during the last stage so that large timbers may be obtained.

Failing adherance to these principles and the carrying out of them properly, means slow growth, low grade timber, low yield, increased disease risk. Open planting also means much greater fire risk.

If the location of the forest has been well chosen, that is, if it is suburban or near the market or near water carriage, and the species and system of planting wisely selected, the thinnings which represent a large proportion of the total produce, can be looked to as the greatest insurance of financial success as they would provide early and repeated returns, and so would prevent the building up against the final crop heavy accumulated charges for the establishment and maintenance, with compounded interest on these and the cost of the land over a long period, which would be the position in the case of a forest that was not thinned.

The forester knows that he must thin and thin frequently, and rather under than over, but he does not know ahead just when each thinning should take place. For this he has, each time, to rely on his own personal judgment, for unfortunately so far foresters have practically no data to go on.

Whilst information has been collected as to comparative rates of growth of various species, practically no investigations or experiments have been conducted in the Southern Hemisphere to ascertain comparative rates of growth of various species grown at various degrees of density and under various conditions.

Collection of some such data, but within restricted limits, is in progress in Europe, but of course, at the best, it will only deal with species of trees grown in Europe and under European conditions, and therefore can be of little, if any, value in connection with forestry operations in southern lands. Especially is this so because the species of trees, the rates of growth, and the general climatic and other conditions are so greatly different from those in Europe.

CHAPTER XIV.

NEED FOR DATA.

As has already been pointed out, the lack of data as to the relative rates of growth under different conditions, especially as to the effect of association of different species, different degrees of density, and different sylvicultural treatment in various ways, is a very serious drawback. Without such data for each country, district, and locality, there is no basis to work upon, and the forester's general and local knowledge, and his judgment has to be depended upon to an undue extent, and among other things it is inevitable that variations in growth, that could not be reasonably anticipated will frequently develop and upset calculations to such an extent that the consequences may be very serious, and that in many other ways, such as time for and degree of thinning, may be misjudged.

This applies both to the selection of species and sylvicultural treatment, which are necessarily, especially in intensive "mixed" forestry, interdependent.

Whilst some private planters carried out work that has supplied some valuable information, State Forest Services have made exceedingly little use of their opportunities. It was certainly the first duty of the various State Forest Services to have immediately, after having collected all information possible from the work of private and communal activities in afforestation in the various districts in the respective countries, to establish widely comprehensive experimental or demonstrative areas. Such should have included all species known to be, or likely to prove, suitable for afforestation purposes in each of the districts in each country, and the experimental operations should have embraced the growing of these species under all different conditions; each variation as to species, mixture, and density being divided into two, one part of each receiving different treatment as to thinning, pruning, etc.

Such work, had it been initiated at the commencement of afforestation operations in each country, would have provided a source of much important information for each country, and would have, years ago, reached a stage from which complete data would be available upon which much of the past and all

the present operation could have been founded, and be available for all future work.

A demonstration area, dealing with several species of much importance in southern lands, with the object of providing comprehensive data that is much needed, as to density of planting, "pure" and "mixed" stands of various characters, the times and degree of thinning in each case, and the comparative rates of growth under each set of conditions and at all times, has been established under the direction of the writer by the Taranaki Forestry Company on its property within a few miles of New Plymouth, in New Zealand.

The operations have been so designed and the records are being kept in such a way that the data that become available from time to time will form a reliable basis, notwithstanding variation in comparative rates of growth in different places, upon which to carry out forestry operations in different districts and countries.

It will necessarily take some years for complete consummation, but owing to the extraordinarily rapid growth that takes place in the situation of the Taranaki forests, in quite a few years some important problems will be solved and much very important information will be gained, all of which will be of great value to foresters, and generally in connection with forestry operations in New Zealand, Australia, and South Africa.

The degree to which the different southern countries have suffered through lack of data such as this differs approximately in proportion to the extent in each of recognition that there has been, and use made, of special talent in forestry.

Though New Zealand has accomplished much in afforestation, judged from the stand of area afforested, coming next to South Africa, she has unfortunately suffered far the most from lack of proper methods.

Though much of her earlier planting was right in method as to spacing but wrong as to location, far the greater amount was so shockingly wrong as to species and that combined with wrong location and neglect, renders much of it practically valueless.

It has been advanced in extenuation of what was done that much of it was really in the nature of experiment. Such excuse is, of coure, absurd, seeing that the so-called experiments were no experiments at all. Some of the species included had been proved, from one end of the country to the other, to be

quite unsuited, and the numbers planted ran into millions when a few hundreds, or at the most a thousand or two, of each would have been ample for any experiment.

As neglect to investigate thoroughly all sources of information that existed, and to carry out, as an initial step, comprehensive experiments from which reliable data could be collected, is so hampering, and as New Zealand affords a conspicuous example of how disastrous and costly the consequence of blind "rule of thumb" procedure can be, the following extract from a pamphlet *Forestry in New Zealand*, recently published is given:—

UNSUITABLE TREES.

Taxpayers' Money Absolutely Wasted.

Whilst private plantations have proved highly profitable, and the work done by them has been commended by foresters of standing, the fact that in the twenty-ninth year of State afforestation operations the paltry sum of £114 was the gross amount that was received from timber sales from plantations, now nearly 80,000 acres in extent, and which stands in debt somewhere about one million and a half sterling, and that the gross total received up to date from the same source is under £4,000, a sum that could easily be netted in the same time from ten acres of private plantation, calls for the fullest investigation.

One valuable service private planters rendered, in addition to that of the actual plantation work, was the experimental and demonstration work carried out in different parts of both islands. Much of this was sufficiently long established before any State afforestation work began, to provide a very extensive field from which much valuable data could have been collected as to the approximate suitability of a great range of timber trees for planting in different parts of the Dominion. All this valuable material was ignored, and to a very considerable extent is still being neglected by the State Forest Service, and the "lucky bag" sort of selection was adopted, and so followed the most wonderful and farcical performance conceivable, as will be seen.

Planting commenced in 1896, and by 1909 11,093 acres had been planted with 33,092,637 trees, equal to 2,983 trees per acre, at a cost of about £5 per 1,000 trees, and by the end of 1913, 20,634 acres had been planted, holding 49,284,280 trees, an average of 2,388 trees per acre, as against the 2,953 per acre of four years before, although nearly twelve million plants had been used to replace failures—22 per cent.

Out of the forty-nine million odd trees planted by the end of 1913 over twenty-one millions were larch planted in pure stand. Long before that time other countries had ceased planting larch in pure stand because of the ravages of disease, and it was only being planted sparingly in mixture. To plant larch to such an extent, not far short of one-half of the total number of trees planted, and to plant it in pure stand, in face of experience, was a mad gamble, and although larch has done in parts comparatively well, there is, even with the best of luck, no hope that it will ever pay.

Next to larch, take the Corsican pine. Whilst it is a valuable timber tree it is over slow in maturing, and the sap wood is of poor quality. It is very doubtful whether the wood of immature Corsican pine trees is as good as that of properly grown pinus insignis. Consequent on its slow maturing quality, it will require a long rotation period, which makes it, grown in pure stand in remote location, more than doubtful of financial success. But while time may prove there was warrant for planting Corsican pine in some locations, there is absolutely no possible excuse for the frightful waste in planting 3,769,431 Austrian pines, the capital cost of which was about £19,000, which to-day stands as an accumulated debit of about £52,000, none of which will ever be recovered. The Austrian pine is a very inferior coarse-grained, knotty form of the Corsican, yielding but a small amount of such poor quality timber. There was absolutely no warrant for planting it, even in the worst situations which have been afforested.

The following gives the number in 1909, and again in 1913, of nine out of about fifty species of trees, which have been planted, also the decrease between the two periods:—

	1909.	1913.	Decrease.
Austrian Pine	3,769,431	3,389,995	379,436
Ash	586,170	584,825	1,345
Sycamore	525,247	303,007	222,240
Walnut	79,027	46,880	32,147
Oaks	2,042,745	369,525	1,673,220
Robinia Pseudo-Acacia (white prickly Acacia)	161,800	29,450	132,350
Silver Birch	252,710	224,415	28,295
Catalpa	2,196,544	27	2,196,517
Totara	546,700	—	546,700
	10,160,374	4,948,124	5,212,250

It will be seen from the foregoing that, taking these nine kinds of trees, of which there was a total of over ten millions in 1909, under five million only remained in 1913; 5,212,250, being well over half the number, had disappeared by 1913,

although nearly twelve million plants had been used to replace failures in the plantations. This 5,212,250 had cost about £26,000, which by now represents an accumulated debit of about £71,000, with nothing, absolutely nothing, left to show for it.

Now just imagine the State in a State afforestation scheme planting over half a million sycamores, and about the same number of ash, 250,000 silver birch, 79,000 walnuts, over two million oaks, and 161,000 prickly acacias (so-called), little better than a noxious weed! Marvellous!

But, bad as these were, they are nothing to the planting of two million odd catalpas! There must indeed have been an exceedingly impish imp in that "lucky bag" to have served out such an assortment. Catalpa! a tree known in its own country as one of the most unreliable, or rather as a sure failure in nineteen out of twenty places, and it had been tried from one end of New Zealand to the other, and, at the best, and that on most rare occasions, produced an ornamental shrub. No wonder the 2,169,544 of 1909 had all but twenty-seven vanished by 1913, and so vanished with them about another £11,000 of the taxpayers' money in first cost, which by now would equal about £30,000 of accumulated debit.

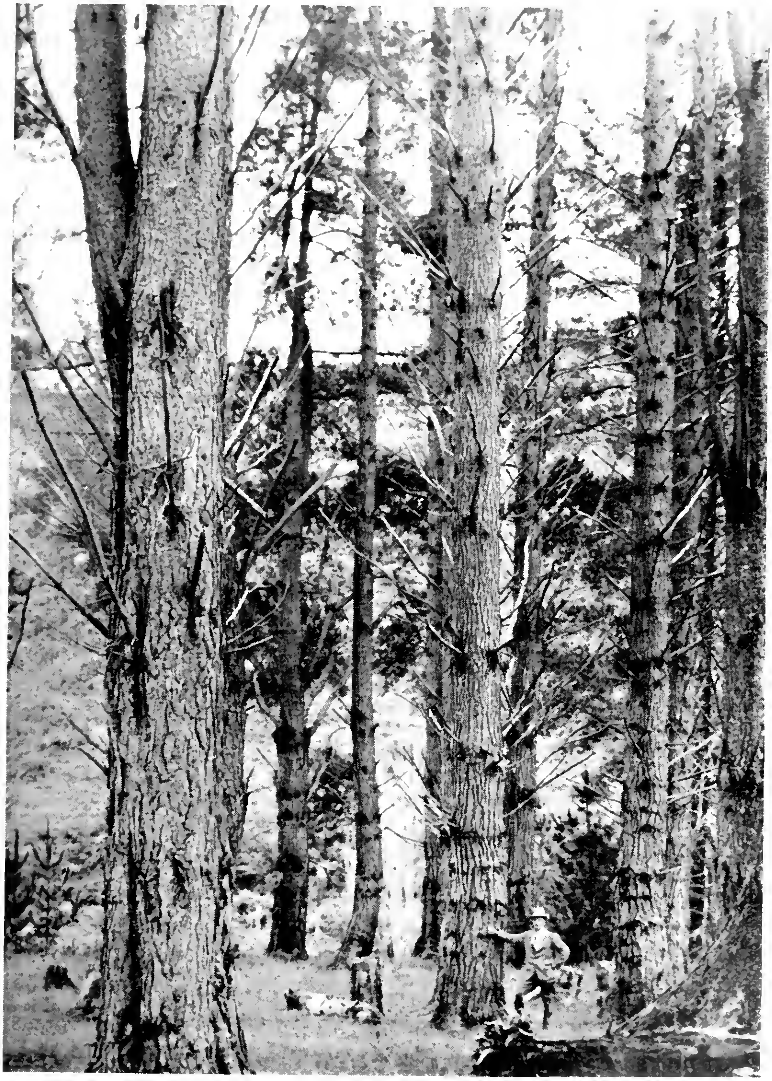
And last of this list, and by no means all, comes the half million totara which by 1913 had all vanished from the State plantations, but unfortunately that was not the last of them, for a number were palmed off on farmers.

Such is part of the history of the "lucky bag" selection system of the early period of State afforestation, and which accounts partly for quite a lot of the expenditure, and a trifle of the loss that will have to be faced.

It would have been well to have left this history of the earlier period alone had there been any assurance that we had come to an end of such experiences. Unfortunately continuance of some of the worst features of the past is not being guarded against. Further reference will be made to this on a later occasion.

Any forestry companies with a history anyway approaching the above would very soon have had to go into liquidation with every penny of capital lost, but, of course, the pockets of the taxpayer come under quite a different category. However, neither past nor present indicate that the "efficiency" boasted of is just the sort either as to protection, management, or direction that forestry enterprises other than State concerns are looking for.

All the planting included in the foregoing reference, in fact all from the inception of New Zealand State afforestation in 1896 until the last ten or twelve years was what might be considered fully dense, the spacing averaging approximately 4 ft. x 4 ft. = 2,720 trees per acre. The spacing has latterly been



Pinus radiata. Over open grown Insignis, timber of which would be coarse, knotty, and third grade. Shown in State Circular No. 3 as ready to cut for building timber.

widened out to 8 feet x 8 feet = 680 trees per acre, one-quarter of the previous number. This change was not made because any information had been gathered as to the most desirable spacing for the production of good timber, but because it was realized that it was impossible, except at prohibitive cost, to thin the plantations in remote places where thinnings were valueless.

This extraordinary change from 2,720 trees per acre to 680—from what Sir David Hutchen termed high class close planting to "over open" spacing that would result in production of timber fit only for box wood—may reasonably be termed a hurried unconsidered endeavour to retreat from an untenable position—wrong location—but through what proves to be a blind alley.

Unfortunately the thirty-two years' experience, though interesting, affords not a scrap of information that was not available before from the experiences of private planters.

Information as to rate of growth of different species, whilst of some assistance in constructing a basis to work on, only goes a very little way.

Particulars as to yields without a complete or fairly complete knowledge of the conditions as to density, etc., at all stages throughout the growth of the trees is of little value further than establishing the fact that, under some quite unknown set of conditions certain results have been obtained. It simply indicates that there are conditions (unknown) under which certain yields are obtainable.

An exemplification of this inconclusive, and therefore almost valueless, information is contained in Circular No. 3 of the New Zealand State Forest Service, issued in the name of L. Macintosh Ellis, Director of Forests. Page 2 displays a picture of a stand of Pinus insignis "Ready for milling into building timber," etc., but the most noticeable thing about it is that the stems from bottom to top are studded with stubs of dead branches. Page 4 has the following:—

"Spacing being from 6 to 10 feet apart. Eight foot spacing is probably the best distance on the average. At any of these distances the branches are suppressed and quickly killed." It does not say eliminated, and the worst thing that can happen is for branches to be killed and not eliminated, and such trees as those shown on pages 2 and 8 covered with firm strong dead branches around the butts of which, from year to year wood has grown, could at the best only produce low grade timber, little of which would be fit for building purposes.

Further information is given on pages 8, 9, and 10 about trees grown on 2·6 acres. The age is given as 46 years, and the number of trees standing per acre as 139. And under "Crop conditions" appears the following, viz.—"The pines have probably been planted at 15 feet apart, or have been well thinned when young." It is clear that nothing whatever is known as to the original spacing, or in fact anything, as to the sylvicultural treatment, and as everything—yield, quality of the timber, etc.—depends upon these, the whole information is worthless so far as being any guide or basis to work on.

The total volume per acre is given as 207,662 board feet, and the annual increment as 627 c. ft. Then on page 4 appears the following:—

Ages.	Number of Trees.	Board ft. per acre.
10	181	7,200
15	175	37,080
20	169	66,600
25	163	103,240
30	157	140,400
35	151	170,640
40	145	190,080
45	139	205,200

This shows that under some unknown condition, from a small area of unstated shape, the final volume was 205,200 b. ft. with an average increment of 4,514 b. ft. is recorded, very high rates indeed. But as to whether the original distance was 4 x 4, or 6 x 6, or 7 x 7, or any other distance, followed or not by careful periodical thinning, or any thinning, or by natural suppression, is quite unknown. The appearance of the trees in the pictures would seem to indicate open planting and early and severe thinning.

The plantations shown on pages 2 and 8 are obviously small and narrow, and cannot be taken as any guide to growth under forest conditions.

Notwithstanding the statement in the circular that the timber was "fairly clean," the appearance of the trees in the pictures, and inferentially they represent the growth referred to, indicates low grade timber. Less than half the yield of high grade timber would probably net considerably more.

Further, it is remarkable that though the State Forest Service plantations were started thirty-two years ago, such information as is given in this official circular has reference to

privately established plantations and not the Forest Service's own work.

The circular above referred to contains on page 4 the following statement with reference to Pinus insignis:—"*Mixture with other species is not permissible owing to the great rapidity with which the tree grows during the first 20 years.*" Whatever may be the case in some particular district this is not a correct general statement.

Insignis is being grown quite successfully in mixture in many places in South Africa, Australia, and New Zealand, and in at least one instance Insignis in mixture is being outgrown to such an extent as to be killed by the other trees.

The South African Forest Department issued a most valuable Bulletin (No. 15), "Pinus Insignis in South Africa," by N. L. King, District Forest Officer, Cape Province.

The Bulletin gives much very valuable information, included amongst which are particulars of yields, etc., of stands spaced 6 ft. x 6 ft., compared with those of stands spaced 9 ft. x 9 ft. Periodical thinning being made in each case.

It would, unfortunately, seem that no comprehensive designed demonstration areas were established in connection with which various sylvicultural methods could have been carried out and from which, from time to time, data could be collected.

Whilst it might have been expected that during later times comprehensive experiments in the direction pointed out would have been carried out in Europe, it is easily understood that in earlier times there would not have appeared any need for anything of the sort, seeing that, as most of the forestry operations were either in the direction of management and improved working of the natural forests, or of afforestation with indigenous trees, of which, what would appear sufficient, knowledge could be gleaned from the natural forests. But the neglect in this connection is absolutely incomprehensible in the case of our southern lands, and especially so in that of New Zealand, which had to depend entirely on exotic trees for all afforestation purposes. South Africa, though not so neglectful, is in a somewhat similar position. Australia, though well supplied with indigenous hardwoods, was poorly so in softwoods, and will have to depend almost entirely for future supplies on afforestation with exotic softwoods.

Chapter XV.

PRUNING.

Shortly the forester's aim is the production of much high-grade timber quickly. Essentials towards that end are dense planting and repeated thinning, for, by such means only, generally speaking, can steady vigorous growth of long clean boles capable of producing straight, dense, even-grained timber free from knots be brought about.

Such growth includes early elimination of side branches by natural means, which obviates almost all necessity for artificial pruning.

If afforestation is carried out on sound lines there should be, with some special exceptions, no need, or at the most very little need, for artificial pruning beyond under special circumstances, the removal of dead branches.

Although at one time when over-wide planting was practised and a very considerable amount of pruning was resorted to, including the removal of much green material, it is now, so far as green material is concerned, very generally condemned as a practice, and resort to it is only recognized as warranted under exceptional circumstances.

If the planting is dense enough very few, and those only weak, side branches form, and are quickly killed and pushed off by the growing timber. Sufficient density should be maintained throughout by rather under than over thinning to prevent, during the greater period of height growth, side branches of any size, or containing any heart-wood, being formed.

A degree of pruning may be warranted under circumstances such as in the case of an irregular and uneven aged plantation where it is desired to annul as far as possible the ill effects of natural conditions or of earlier neglect, or in the case of over open spacing where natural suppression and elimination cannot take place quickly enough. But the expense of any extensive operations would be prohibitive.

The side branches of some species of hardwoods and of some softwoods are very persistent, but much even in such cases can be done by density of planting and by judicious mixture.

Maw says in *The Practice of Forestry*—"Side branches must be naturally killed before they are too big to readily drop off; in other words the trees must be planted so close that large side branches can never develop."

That is a very clear exposition of a principle that should always be followed.

Sir William Schlich, in Vol. II., page 298, has the following: —"Trees which grow up in crowded woods lose the lower branches naturally, owing to the insufficiency of light, and this process proceeds up the stem with the elevation of the leaf canopy from the ground."

A. G. Forbes, in *English State Forestry*, page 145:—"But the fact is either ignored or lost sight of, that the necessity for pruning can be avoided to a great measure by sylvicultural mixtures, or maintaining the crop at a proper density."

Professor Charles E. Curtis, in his *Practical Forestry*, 1920, has the following:—Page, 56—"The lateral branches must die off, and not be cut (in fact, pruning of any kind is an evil resulting from the neglect of well-known rules, and should, in really good forestry, be unnecessary); and to secure this the trees must be sufficiently close. If too close, however, the branches will die off before they have performed their functions; if too wide, it will be necessary to cut them off, which, as before stated, results in injury to the future timber."

What Professor Curtis implies by too close and too wide can be judged by the following:—"In my practice—and I have had time to prove its efficacy—I plant 4 feet apart on the equilateral principle."

Professor Curtis, in saying "that pruning of any kind is an evil resulting from neglect of well-known rules and that it should in really good forestry be unnecessary," expresses what is now generally held by foresters to be the only sound practice, for though there are some few species which are planted for timber production in the Northern Hemisphere that are not entirely responsive to this treatment, it is an absolutely sound rule to follow in afforestation in our southern lands, for no other course is economically practicable unless under some special conditions, such as in the case of a small number of trees (the side branches of which are persistent) per acre which have been planted to compose the final crop, proper density being obtained by planting of other species which are all to be cut out in thinnings and intermediate crops.

However, there may be conditions, such as already mentioned, under which it may be desirable to carry out some artificial pruning.

The advantage of pruning is that the removal of side branches, if not overdone, tends to

(1) More vigorous height growth.
(2) Lessen taper.
(3) Prevent or lessen knots.
(4) And in the case of dead branches, prevent dead wood being embedded in the timber.

Apart from close pruning the cutting back of branches which are crowding or overshadowing other trees is often advantageous.

The disadvantages of pruning are:—

(1) It is usually excessively costly, and on that account can only be carried out in special cases and to a limited extent.
(2) It requires considerable skill and care or more harm than good will be done, and therefore few can be entrusted with the work.
(3) Frequently, especially in the case of those trees lacking full vigour of growth, it exposes the trees to attack by disease and insects.

Before proceeding to indicate where, how, and when artificial pruning may be undertaken, it is well, as the chief object of pruning is to prevent knots, to be clear as to the different kinds of knots and their effect.

Some species of trees if grown separately or very widely spaced will grow very many side branches—in the case of some species many slender ones and in that of other fewer but heavier—which will rapidly form heartwood and become strong. In most cases so long as these branches remain green and continue to grow, the timber will not suffer very much injury, in fact, in some instances, such as with some ornamental timbers—the growth of knots—so long as the grain is close—due to the continuance of growing side branches, adds to the beauty and value of the timber, but the timber will be less even, and less straight in grain, and of less strength, and so for structural purposes it will be faulty, but the degree of blemishes will not be serious. Therefore independent trees and those which have been so widely spaced that the side branches have continued to grow, whilst having considerable

taper and wasteful and costly to convert, will produce quite saleable timber.

On the other hand should the side branches die owing to the nature of growth of the tree or the later closing in of the canopy, so excluding the light, the whole position will be altered, for either the side branches must be removed each season as they die, or then each year's growth of timber around the stem will enclose dead wood, each piece of which will become a "cork" or "loose" knot, and the resultant timber will consequently be of very low grade or almost worthless.

It follows that "over open" planting, such as 8 feet x 8 feet, which permits, as for instance in the case of Pinus insignis, the growth of strong lateral branches for several years, followed later by a closing in of the canopy causing all the lateral branches to die, results in a position practically impossible to deal with.

During some years of the free growth of lateral branches unduly rapid diameter growth would take place, resulting in wide annual rings of soft open-grained timber full of "fast" knots, and whilst it would be practicable to prune off some of the lower lateral branches, the same condition of strong lateral branches, later dying, would continue right up the stem, and the cost of carrying out effective pruning would be altogether prohibitive, exceeding many times over what would have been the cost of a proper closely spaced plantation. Failing pruning, the dead stubs would become embedded, resulting in numerous "loose" knots.

The pruning of dead or even green lateral branches would be warranted in such cases as in, for instance, an otherwise satisfactory plantation, where having places where, through failures of a few trees, part had become too openly spaced or where, for some other reason, the lateral branches of a few trees were over persistent. Also along forest margins, including particularly the margins against fire-breaks, forest roads or tracks, where the removal of all inflammable material under the trees for a depth back of several trees, should always include the removal of all dead branches.

Dead wood.—So far as the cost will permit, the removal of all dead wood, if properly done, cannot be other than a benefit, and, therefore, in every case the special circumstances and degree of advantage must be taken into consideration in judging whether the expenditure is warranted or not, but it may be taken as certain that under no ordinary circumstances

is it economically possible to rectify the ill effects of "over open" planting by pruning.

There is one class of plantation where artificial pruning may be practised without too great cost and with distinct advantage, that is where a "mixed" plantation has been established, so that a small proportion only of the trees planted will compose the final crop, and these trees being of a kind that will not readily shed their lateral branches, may have a proportion of these removed from time to time.

Green branches.—The pruning of green branches is highly undesirable, and should only be resorted to under very special circumstances, and carried out only to a limited extent, and at the right time, and only by one who has skill and knowledge.

The removal of double stems is always warranted, and, usually also is that of any proportionately extra heavy branches that are likely to interfere with well-balanced growth or unduly crowd other trees.

If for some reason some pruning of green lateral branches is undertaken it should be limited to not more than at the most a proportion of one-fifth of the total on a tree. The removal of any larger proportion of green branches seriously checks growth, and is likely to injure the health of the tree.

The more regularly planted and the more fully stocked a plantation is the better, and the less pruning, if any at all, will be required. But even if well established, neglect of the plantation will soon result in considerable deterioration and a certain amount of pruning and stopping back of branches may have to be resorted to.

During early years of establishing a plantation conditions of growth may warrant a certain amount of stopping back of side branches that tend to overshadow or overcrowd other trees, and some close pruning and stopping back of branches to check the growth of over fast trees, at the same time giving more light and room to backward ones.

All pruning should be done at the earliest stage possible. The larger the branches have become the more undesirable, and the more costly, will the operation be.

Maw, in *The Practice of Forestry*, says:—"In the case of conifers an almost invariable rule should be observed, namely, 'never prune a green branch.' One great reason for that is the danger of insect and fungoid attacks is so very much increased by the operation."

But in connection with this it has to be borne in mind that the risk is much greater in colder climates such as northern and middle Europe than in warmer, and in the sub-tropical nature of the climate in much of our southern lands the risk is not great where dealing with most species, especially if the work is carefully done and done at the right time, but in the case of some species the risk is so great, or it may be said that disease and insect attack is so certain that artificial pruning should on no account be attempted. Such for instance as the Blackwood (*Acacia melanoxylon*) the pruning of which is invariably fatal. On the other hand Black Wattle (*Acacia decurrens*) and some of the other Acacias stand pruning and cutting back very well.

Generally speaking, besides the risk of fungoid and insect attacks, pruning done at the wrong time or done carelessly will often do more harm by far than would result if not done at all.

Time for Pruning.—Here again climate is a most important consideration. The rapid growth in our warmer climes gives us a much freer hand.

In Europe the question of the most suitable time for pruning is far from settled. Some authorities, such as Schlich, lean towards the dormant period because of the greater risk of fungoid and insect attack during the growing period, and because wounds cannot be successfully treated with pitch, tar, oil of turpentine, or such like whilst the sap is flowing.

From actual experience in our southern lands the most vigorous growing season is far the best. If the cut is made clean and close without injury to the surrounding bark, the wound will be so quickly covered over that no drying or cracking of the wood has time to take place. But it must always be remembered that the smaller and younger the branches are the safer and more surely successful will the operation be.

Through accident or for some special reason the removal of larger wood may be desirable, but the avoidance of blemish in the timber or other injury is much less assured.

How to prune.—Whether it is dead or green wood that is to be removed, the cut should be a clean upward cut, made quite, or as nearly as possible, flush with the stem, but without injury to the bark of the tree. It has to be remembered that during the most vigorous growing period is the time when bark is most easily raised from the wood, and therefore especial care is necessary that whatever tool is used it should be very sharp, and the cut should be made quite clean and

upwards, and in such a manner as to prevent any side movement or pull or pressure on any part of the bark. Raising of the bark from the wood around the cut is especially liable in case of Eucalypts.

The smaller the branch the easier it is to make a clean and very close cut without doing any injury, and a very sharp strong knife, or double-edged secateurs will usually answer the purpose, but if the branches are larger and harder, the operation will be far less easy and the risk of injury to the bark much greater, and a stronger tool than a knife or secateurs will be necessary.

For larger branches a saw will have to be used, but for lesser ones, but such as are too strong for a knife, a rather thin slight curved hook, with the curve short and near the end, used with a mallet, with which to strike it upwards, is a safe and effective tool. A chisel, somewhat like a thin broad mortise chisel, slightly gouge-shaped, can be used with a mallet.

Light axes and slashers are being used, but should be absolutely condemned by any forester who knows his work, for it is practically impossible, even if carried out by an expert hand, to do work with such tools without a very high percentage of defective cuts resulting either in the collar (stem bark round the butt of the branch) being injured or then a stub being left. On no consideration should a ragged cut be made, or the face of a cut in the tree have the least split, or any injury be done to the bark of the tree, and above all not the least sign of a snag or stub should remain, for if any such remains a very serious flaw will at the best result, besides which a risk of injury through fungoid or insect pests will be incurred.

When work is not done with the object of eliminating lateral branches but only to shorten them so as to prevent crowding or overshadowing, or in conjunction with a rather severe removal of lower branches, to check the growth of over-rapid growing young trees so that the slower ones may catch up, or when the work is in the nature of trimming an outer face of a plantation against a road or fire-break, the cutting back of branches is an entirely different operation. It is not nearly so risky, as it does not involve, if well done, practically any insect or disease risk, nor is there risk of any injury to the bark of the tree, nor any need for exactness as to the place of the cut, and so can be well and rapidly done with slashers or any such like tools by any reasonably good workman.

CHAPTER XVI.

LOCATION.

Here in using the term "Location" it is used in the more usual sense to indicate position in relation to other places and not, as used in some works on forestry, with reference to the peculiarities of the situation as to climate, soil, aspect, etc.

It is hardly an over-statement to say that in commercial forestry everything depends upon location.

No matter how rapid the growth of the trees, how great the yield, and how high the class of timber produced, the inability to dispose of the thinnings and small wood and the excessive cost of haulage on all material produced through remoteness from a market may render the undertaking a financial failure. In other words the finest forest fully stocked with the best timber may be valueless because it is inaccessible, or because the cost of haulage added to other costs exceeds the market value of the timber.

Further, high-class intensive forestry cannot be practised in a remote location for the same reasons as already given, and therefore high grade timber cannot be produced.

The all-important question of location, for obvious reasons, hardly arose in the past, for in the different countries where more or less scientific methods were applied to forestry and afforestation, there were natural forests or woods or long-established plantations generally scattered over their whole areas, and further the earlier conservation and afforestation was largely in the hands of private individuals or were communal and not State owned.

Under private or communal enterprise, conservation would largely, and afforestation still more so, tend to be widely scattered in many places, and to a great extent to be more or less suburban.

By whom European Forests are Owned.—Bearing in mind how widely scattered over the whole area are forests in Europe, and how many suburban or semi-suburban forests there are around Paris, Brussels, and other cities, it is significant and interesting to note the relative ownership as between State and non-State in the various countries of Europe, as displayed by immediate pre-War figures.

The following are the percentages of forested areas held by other owners than the State:—

Great Britain 97, Italy 96, Belgium 95, Switzerland 95, Austria 93, Portugal 92, France 88, Hungary 85, Denmark 76, Norway 72, Bulgaria 70, Sweden 67, and Germany 66.

Professor Curtis, in his *The Management and Planting of British Woodlands*, says:—"The common idea that our waste lands should be planted, is based on a misconception of facts. True, if waste lands are situated near roads and railways, or within profitable reach of markets, such an investment of capital would be wise; but if they are far away from both, as they chiefly are, such an investment is likely to end in failure."

Government authorities.—With the advent of Government authorities into afforestation activities, the distinct tendency has been to allow the lowness of the value of the land to be the deciding factor in the question of location, ignoring all other considerations.

Whilst there might be some excuse, though no real warrant, for such an attitude in connection with forestry for timber purposes in countries in the Northern Hemisphere where tree growth is very slow and population is dense, there is no excuse or warrant whatever for the same attitude by governments of our southern lands, where all the conditions are entirely different.

The fetish of cheap land.—The fetish of cheap land has imposed itself in many countries, including those of the south, but it has New Zealand as its chief exponent.

Leaving out of consideration here "Protective" and "Reclamative" forests, the main objects of which are not the production of timber, and also apart from forests which may be established for the production of large quantities of material for some special purpose of manufacture or extraction—such as wood pulp—near the forest, remote forests, that is, those which are remote from centres of population or close settlement, or from means of water carriage, must always be under very heavy disadvantages, such as heavy haulage costs on all forest produce, lack of markets for thinnings and all small wood, and as a consequence debarred from adherence to proper principles of forestry and sylviculture except at prohibitive cost.

The fetish of cheap land has played such a very serious part in afforestation activities, especially so in the various State undertakings in southern lands, that it is most important

that there should be a clearer conception of what is implied by scientific forestry, viz., the production of good timber quickly, at low cost, and a better understanding as to upon what factors the ultimate cost of timber to the consumer chiefly depends—assuming that it can be sold at cost price.

Of what the Cost of Timber chiefly consists.—The ultimate cost to the consumer is made up, in the main, of the following several charges:—

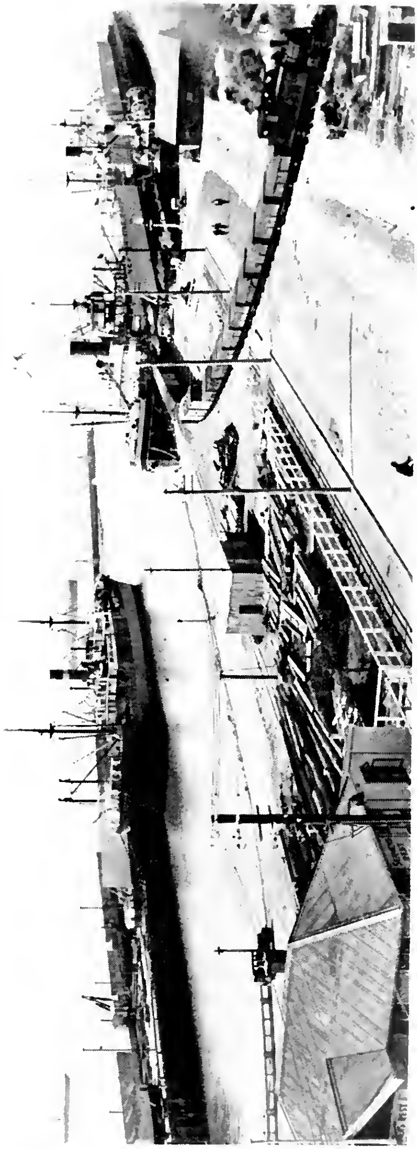
Cost of (1) land, (2) establishment, (3) maintenance, (4) fire, disease, and other risks, (5) felling and removal from the forest to the mill, (6) conversion, (7) haulage, freight, etc., (8) sale, (9) overhead charges, and (10) compound interest on the net debits.

Of course the amount of the yield and the class and the grade of the timber produced are inseparably involved in the above, and it will be found that those and the cost of haulage and associated charges and the accumulated maintenance and interest charges, or in other words "time," are by far the greatest factors.

As a preliminary, so that it will be in mind, whilst considering the other features, it is well to indicate how great a factor compound interest charges—"time"—may be, if the time is prolonged before a return is obtained.

It has been contended by some, even by foresters of some repute, that the idea of compound interest is just a bogey and that it should not be taken into account. Forestry undertakings should and must be treated on proper business lines, and the cost of capital sunk in this, as in any other undertaking must be taken into account. The private investor will look for a return for his capital that will at least equal the annual interest obtainable from ordinary investments, and State forestry undertakings should, at the least, aim at recoupment of, besides the capital, the interest paid on State loans out of which they are financed.

As location and the influence that the fetish of cheap land has had on the choice of location is being dealt with, it is well to compare what would apply to a remote forest where the cost of land would be very little, or even nothing at all, but from which, owing to its remote location, no early returns could be obtained, as thinnings would be unsaleable, with a forest located near a market—say a suburban forest—where high-class intensive forestry could be practised because thinnings and small-wood would be saleable at a profit, and therefore against



Port of New Plymouth with five overseas vessels. This port is within seven miles of the Taranaki Forests – Suburban Forests.

such a forest there would be no accumulation of charges building up after about the tenth year.

Assuming as a first charge £5 per acre for establishment and nothing for land in the case of a remote forest and £10 per acre for establishment and £10 per acre for land in the case of a suburban forest, and £1 per acre per annum in each case to cover maintenance, protection, risks, rates and taxes, and other overhead charges.

The following table displays what would be the position as to accumulated charges per acre, on a 5% compounded interest basis, at the different periods given. In the case of a remote forest where no early returns could be obtained and in the case of a suburban forest where charges against it would be cleared off within an early period.

Comparison of Accumulated Charges.

Remote Forest.

Years.	Cost of Establishment at £5.	Annual Charges at £1.	Total.
10	8·14	12·57	£20·71
20	13·26	33·16	£46·42
30	21·60	66·43	£88·03
40	35·19	120·79	£155·98

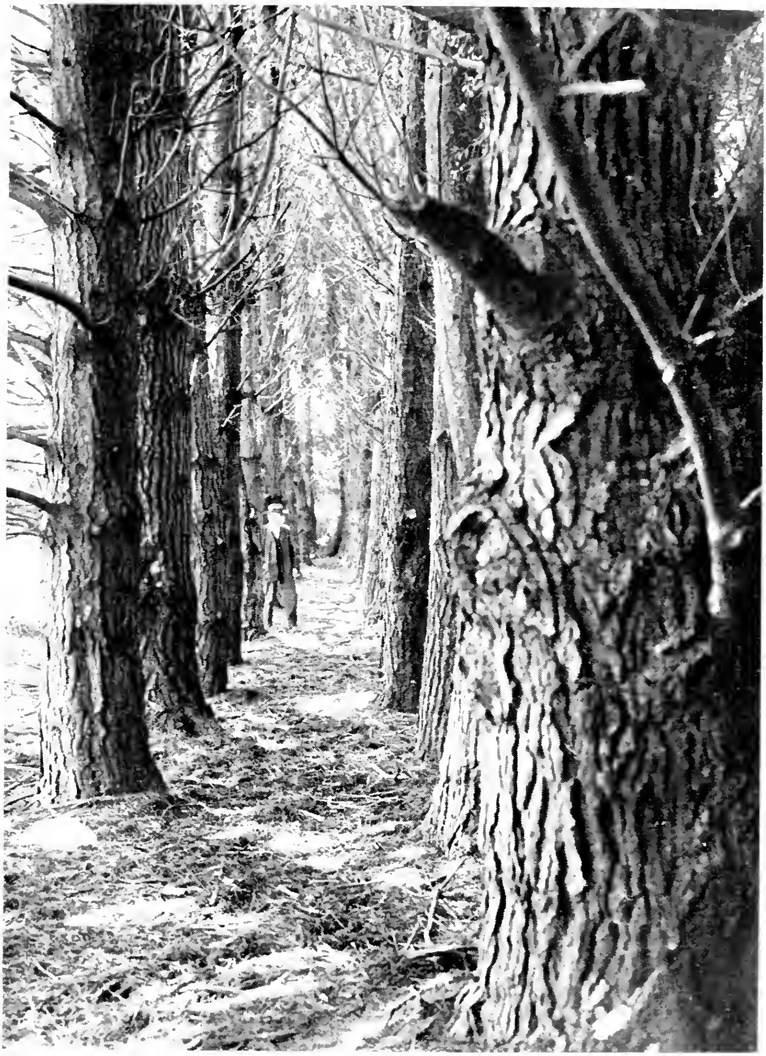
Suburban Forest.

Years.	Cost of Land at £10.	Cost of Establishment at £10.	Annual Charge at £1.	Total
10	16·28	16·28	12·57	£45 13

It will be seen that the remote forest would have an accumulated debit against it of £88 per acre at the 30th year and £156 at the 40th year; whilst in the case of the suburban forest, though starting with a cost of £10 per acre for land against nothing in the other case, and £10 per acre cost of better establishment as against £5, the total debit against the suburban forest would only be £45 2s. 5d. per acre, to be met by sale of thinnings in the tenth year.

The heavy accumulated debit is but one of the many disadvantages of remote location.

In view of the approaching famine in softwoods, due to the enormously increasing consumption, and considering the very small proportion of softwood grown in southern lands, afforestation with softwoods as the main crop, but not in pure stand, must take a place far beyond that of hardwoods, and as Pinus insignis has been proved an exceedingly rapid growing



The sort of over open grown Insignis pine, the milling of which brings the timber into bad repute.

tree (estimated to grow 30% to 60% faster than any other pine), and a surer grower than any other in South Africa, Australia, and New Zealand, it is reasonable to take it as the standard.

Yields and costs of haulage, etc.—Actual yields of Pinus insignis have reached over 200,000 sup. feet, and under proper methods of afforestation and sylvicultural management the total timber per acre that can be grown would largely exceed the above. However, 150,000 sup. feet per acre in 30 to 35 years can be taken as a sound basis to work on in New Zealand, and over 100,000 in South Africa and Australia.

A near located or suburban forest, such as the Taranaki Forests, which are within a few miles of New Plymouth town and port, where intensive afforestation and proper sylvicultural methods could be practised, means among other things dense planting and many thinnings, or rather some thinnings plus intermediate crops.

Dense planting and repeated thinning results in high yield and highest grade timber—a yield in practice approximating the theoretical. A yield approximating 100% of the theoretical as compared to 66% practical conversion of low-grade timber from over-open planting.

Low grade timber is a drug in the market at prices from one-half to one-third or less of that of high grade—£1 against £2 to £3 or even more. And this position cannot be other than accentuated in the future, seeing the great extent of "over open" planting that is being carried out, and which cannot do other than result in a flood of low grade material.

Near market or suburban location where intensive forestry can be practised means early returns, as all thinnings—fuel, fencing, poles of all kinds, sleepers, piles, props, etc.—can be sold at a profit, whilst in the case of remote forests the heavy haulage costs make the sale of all earlier thinnings impossible, though later intermediate crops may be made to pay costs, but all small wood would be worthless.

The sales from near located or suburban forests would commence at from the eighth to the tenth year, and these would at least clear the forest of all charges, so there would be no debits to accumulate at compound interest, against any of the later crops, whilst in the case of a remote forest there would, on the basis shown in the table, at the 30th year be an accumulation of £88 per acre, or at the 40th year £156.

The next disadvantage in remote location as compared with a near market or suburban, is that in the case of a suburban

forest, which permits high class intensive mixed forestry, a yield of 200,000 sup. feet, mostly high grade, can be ensured, whilst in the case of a remote forest, where intensive forestry cannot be practised, a yield of exceeding 120,000 sup. feet, mostly low grade, cannot be counted on, even in a 40 year period.

In connection with the question of comparative yield, it has been shown by actual measurement that the yield of a 6 ft. x 6 ft. spaced crop, counting thinnings, exceeded that of a 9 ft. x 9 ft. spaced crop by 40% and the loss in actual conversion of the latter would much exceed that of the former.

The next question which, next to that of grade, is the most important, is that of haulage.

Assuming that the total cost, made up of felling, haulage to the mill, conversion, haulage to and loading on the railway trucks, and unloading and carting from the railway to the builders' yards was only equal to total cost from the suburban forest to the builders' yards and assuming 100,000 sup. feet only per acre to be hauled by rail, the disadvantage in this direction alone to the remote forest as compared with the suburban would be the amount of the railway freight for whatever the distance.

So that some fair idea of how great a charge per acre the matter of haulage may be, especially on the low grade product of a remote forest, the actual position of the New Zealand State forests near Rotorua and the New Zealand State railway tariff may fairly be taken.

The distance of Rotorua from the city of Auckland is 171 miles, and the nearest part of the forests is several miles from the railway terminus, and other parts are a great distance, which would entail excessive extra haulage costs to the railway far beyond those from a suburban forest to the builders' yards.

The tariff railway freight on timber for 171 miles—the distance from Rotorua to Auckland—is 5/4 per 100 sup. feet (on 100 miles it is 4/5, and on 150 miles 5/2). The rate from Rotorua, 5/4 on 100,000 sup. feet would amount to a charge of £266 13s. 4d. per acre, and that on low grade timber, plus an accumulated charge of £156, or a total disadvantage on those scores alone of over £420 per acre, with much less yield and lower quality than that of a suburban forest.

It has been very truly said that the suburban forests carry the remote ones on their backs. That any forest producing low grade timber, except for purpose of manufacture of wood

products on the ground, could stand such a crushing charge per acre on these two scores alone, in addition to all the other costs of exploitation is not conceivable, and afforestation on such conditions is unquestionably economically unsound, for it could not be financially successful unless the consumer was, through a monopoly, forced to pay an unduly high price for the timber.

To summarize—The foregoing is not suggested as any exact statement, as conditions and circumstances are so varying that it is impossible to give more than approximate comparisons, but a consideration of the subject and the advantages and disadvantages disclose the following:—

Suburban or near location permits intensive afforestation and high grade sylvicultural methods because thinnings and small wood of every kind can be profitably disposed of, and establishment, maintenance, and all other costs can be early recouped, so preventing any accumulation of charges against later crops.

Near location, together with more favourable situation as to climate, aspect, soil, and configuration, which may be obtained by paying a considerable price for the land, will permit of intensive mixed forestry, with a wide range of choice of the more valuable species, and so ensure returns that will outweigh many times over the cost of the land.

Dense planting and repeated thinning under proper direction will ensure high yields and high grade timber.

All forest material, including the later crops, will escape the heavy haulage and extra handling charges to which crops of remote forests would be subject.

Suburban forests and those in closely settled districts would, in addition, afford to the fullest and to the greatest number all the climatic and æsthetic benefits of afforestation.

Remote forests would, because of the inability to market any early thinnings or any small wood, be subject to such heavy charges on account of cutting and removing from the forest to waste all such material, that intensive afforestation and proper sylvicultural treatment could not be profitably carried out, with the result, first that charges would accumulate and that the intermediate and main crops would be less in yield and lower in grade, and the cost of removal from the forest and preparing the logs for the mill on account of heavier branching, taper, and roughness, would be considerably

greater. And further, the cost of the lengthy railway or other haulage charges on those low grade products would, alone, far exceed many times over, the extra cost of land in better location.

Chapter XVII.

VALUES—MARKET.

It has already been pointed out that forestry does not consist in covering large areas of land with trees planted anyway, nor in growing trees well without regard to the market.

The forester's business is to grow in the shortest period of time the largest quantity of timber that will reasonably serve the special requirements of the available market, at the lowest possible cost, as near as possible to the market or point of export.

Timber of the highest quality, grown at low cost, may yet be valueless because of the location of the forest—because too distant or inaccessible.

Timber of inferior quality may, because produced cheaply close to its market, be of much value.

Timber of certain quality may be of little value because the market is over supplied.

Timbers from species of known high class, costly to grow, may, being of low grade, be of little value because high grade timber of inferior species produced more cheaply, may answer the demand as well, or even better. As an instance, the timber of Redwood properly grown and matured is unquestionably of very high quality and durability, and it has a very wide range of utility, and whilst it is one of the most valuable timbers, it is not used where great strength is required, but as a result of a comparison being made by the New Zealand State Forest Service between low grade Redwood grown under improper conditions—equivalent to absurdly "over open" spacing—Redwood was described in the New Zealand State Forest Service price list for 1927 as "fit for boxing and crating, and other purposes where great strength is not of paramount importance."

Apart from the absurdity of comparing the timber of Redwood grown under such conditions as to induce an average

diameter growth of an inch a year—timber only showing two annual rings per inch—with fine-grained timber showing nineteen annual rings to the inch, low grade Redwood is less serviceable for boxes and crates, being soft and brittle, than good grade Pinus insignis, which can be grown more quickly, at much less cost, and can be grown in situations and under conditions where it would be impossible to grow Redwood.

The one quality that the otherwise exceedingly valuable Redwood, even of the highest grade, lacks is strength, and one of its greatest qualities is durability. Timber for boxing and crating requires to be fairly strong, good nail-holding, but durability or great strength is not required.

Obviously to grow or use Redwood for case timber would be absurd waste.

Location and demand, or market, are two most important factors, and it follows that the market, or rather the prospective market, and facility and lowness of cost in getting to it are among the forester's chief considerations.

There can be no advantage in producing that which will have no sale value, or the sale value of which will be less than the cost of production. Therefore, having decided upon the location and the situation, it is the forester's duty, and a very important duty, from amongst such species as will thrive well and grow rapidly under the conditions under which they have to be grown, to select such species as he judges will, according to the order in which they should be ready for disposal, most suit the market they can command. It may be a local market for fuel, fencing, poles, and timber, or for wood for pulping or such like, or for timber for export, whichever need can be supplied to the best advantage.

High grade timbers, no matter of what class, will command ready sale at relatively high prices, and for some purposes will be preferred, at those prices, to lower grade timber of a higher class at much lower prices. There are, of course, some purposes for which bulk and lowness of price are most important.

Whilst the consumption of softwood is approximately 80% to 20% of that of hardwood, with a tendency to an even greater production of softwood, the almost general practice in southern lands, especially in New Zealand and Australia, of "over open" spacing must result in a very excessive proportion of low grade timber, an amount that will far exceed local demands for uses for which low grade timber can be put as

timber, consequently the only market, though possibly an almost unlimited one—assuming export—will be that for conversion into wood-products, but for such purposes the wood has to reach the place of conversion at a *very* low cost, and whether it can, under conditions obtaining in Australia and New Zealand, be grown, hauled, etc., at a sufficiently low total cost is open to question. Exported material will have to face heavy duty, or long sea freights, or both.

Chapter XVIII.

SITUATION.

The term "situation" is used here to denote the position as to physical surroundings. As before mentioned, the term "location" is used in this work not to denote physical surroundings, but relative positions as to nearness or otherwise to market, waterways, etc.

Assuming fully qualified direction throughout, the two factors upon which economic and financial success will most depend are "location" and "situation." Therefore, having already dealt fully with "location," the subject of "situation" naturally follows.

"Situation" embraces the three matters (1) Climatic conditions, (2) Soil conditions, and (3) Configuration, including aspect.

Tree growth depends more upon climatic conditions and the mechanical condition of the soil than upon the fertility of the soil.

Rainfall.—The degree of rainfall that is most beneficial to tree growth cannot be fixed, even within wide limits, as it varies so greatly with the temperature, degree of atmospheric moisture, aspect, exposure to prevailing winds, mechanical conditions of the soil, the species of trees, the density at which they are planted, and the extent of woodland in the vicinity. A rainfall of from 50 to 80 inches, fairly distributed but rather more in the winter than in the summer, might be considered very favourable under many conditions, though very much less, even to under 20 inches, will do under certain conditions for some species, whilst many species will thrive excellently in places where the fall is very much greater.

Protection.—More important than a heavy rainfall are, protection from too rapid evaporation, general humidity, absence of, or protection from drying and cold winds. Semi-coastal areas, if not over exposed, backed by high country, would appear to be generally favourable.

Straight, long length, valuable timber cannot be grown if the trees are subjected to extreme or even severe exposure, and therefore if such a situation has to be dealt with, adequate shelter should be provided before planting.

Temperature.—No part of our southern lands is too far south for satisfactory tree growth, or even for growing of a fairly wide range of species, and as high temperature is conducive to growth of most species that it is advisable to grow in southern lands provided the humidity is sufficient, therefore if the elevation or exposure is not too great, lack of sufficient rainfall is the deciding factor and not too low or too high temperatures.

Some few species, such as Pinus sylvestris and some of the Spruces, which belong to the colder zones of the Northern Hemisphere, have been grown in districts in the southern lands where the climate is too mild, with the result that they are succumbing to disease. The attempt to grow such species should either be abandoned or then confined to the higher elevations, or, in the case of New Zealand, to the southern part. But in any case, the planting of such species to any considerable extent will be attended with much risk.

Heat combined with moisture is a very great factor in the rate of growth and the range of species from which choice may be made.

A sufficiently high temperature during the growing season, though followed by much lower in the winter, is more important than an approximate average of the two throughout the whole year, but in practically all parts of our southern lands, except at high elevations, the temperature is sufficiently high throughout the greater part of the year, if combined with sufficient moisture, to cause rapid growth during a very long season.

It is chiefly because these conditions prevail over considerable areas of New Zealand that tree growth is so rapid there, and that that country is undoubtedly destined to become, for its size, the greatest timber producer.

Notwithstanding the general high temperature of these lands and their comparatively mild winters, there are, of course, many areas, being inland, or at high elevation, or in

sheltered low-lying southerly aspects, which suffer from severe frosts. Such situations should if possible be avoided, but if planted for reasons such as being parts of areas the whole of which it is desired to plant, frost-resisting species ought, of course, to be chosen. Most of the important pines and many valuable hardwoods are sufficiently frost-resisting, but of all, Pinus ponderosa is perhaps the most so.

Aspect.—The most suitable aspect is also largely dependent on the species, rainfall, temperature, nature and depth of the soil, and exposure, but generally speaking, a northerly aspect—that is to the sun—is the best, provided there is sufficient moisture.

Soil.—For the reason that trees draw their sustenance largely from the air and from the acids and moisture from deep down in the subsoil, the depth and mechanical condition of the soil is generally speaking far more important for tree growth than its degree of fertility.

Many pines and some other trees will grow—other conditions being favourable—excellently, or even sometimes better, in second class or even really poor soils than in rich, but there are many exceptions where fertility of the soil is very important. Also in the case of seedlings and young trees, up to the time that their roots are striking down into the soil, fertility is of distinct importance.

It is most desirable that the soil—the term to include subsoil—should be friable and deep, but not too loose or too porous. The most beneficial degree of porosity, within the limit of being firm enough to hold the roots, depends upon the depth, the rainfall, and protection. A very deep, porous, and well-drained soil, with ample or heavy rainfall well distributed throughout the year, with a good prolonged summer temperature is ideal for rapid healthy growth.

In actual experience in a situation where the soil is exceedingly friable and porous to a great depth—20 feet and over—Pines and Eucalypts of many species have made extraordinarily rapid growth, but the soil is well drained and the rainfall of about 70 inches is well distributed throughout the year. Such conditions afford great advantages. The soil becomes heated to a considerable depth during the summer, and owing to that and that no water lies anywhere near underneath, the growing season is much prolonged, and there is an almost complete immunity from frost.

The deeper the soil the better. Any hard or impervious stratum is most undesirable, for, whilst some species will grow well for a time in comparatively shallow soil, underlaid by rock or other hard-pan, the trees will seldom continue healthy vigorous growth for long, for depth of rooting is prevented, and the roots are subjected to extremes of wetness and dryness. If the forest floor is well built up and a complete canopy is always maintained, and if the situation is not too wet, trees may continue to thrive in over-shallow soil, but there must always be a great risk of windfalls during storms, and especially great risk when thinning.

Whilst it is not desirable that the soil should be over dry it is most important that it should not be over wet or swampy, and above all there should be no stagnant water. Draining should, if reasonably practicable, be resorted to under such circumstances, but if this cannot be done on account of expense then species specially adapted for such situations should be selected. Such species are few, but so long as the water is not stagnant several of the Eucalypts and others will grow.

The forester should aim at protecting and improving the soil by so planting as to create humus, and to maintain an evenness in degree of heat and moisture.

Configuration plays a very important part in the cost of establishment and maintenance, in the choice of species of trees, and in their development, and especially in the cost of exploitation.

Level land, with favourable soil conditions, offers great facilities and very considerable advantages, especially as to all costs, but except in the case of remote forests level land will not often come under consideration, as in advantageous locations level land would seldom, except to a small extent for protection and beautification, be available for afforestation for timber production as it would usually be required for other purposes.

Taking the other extreme, very broken rugged country, with deep gullies, steep sides, and high narrow spurs is exceedingly difficult and costly to prepare, plant, and maintain properly, and the logging and hauling, with some exceptions, are still more difficult and costly, and must subject the crop to a heavy toll, and in most instances it would be impracticable to utilize the earlier thinnings or anything but the larger timbers.

On the other hand country of this description may, in exceptional cases, be suitable for profitable afforestation for

timber purposes, though costly and difficult to establish and maintain, as for instance when the ravines have bottoms suitable for easy haulage, or transport by water, with their exits towards easy and reasonably short transport facilities. But should the ravines lead towards remoter country or country costly and difficult of access, or if long uphill haulage is the only means by which the logs can be got out, afforestation, whilst possibly advisable for climatic or protective reasons, would be distinctly unsuitable for timber purposes.

An English forester, in referring to the value of timber standing, wrote somewhat in these words:—"Another point upon what the value of timber depends, is the position in which it is standing. This is an important point which is frequently overlooked. A bulky article like timber growing in broken ground, a considerable distance from good roads, the cost of transport is a very important factor in the expense of conversion."

Now turning from the two extremes, level and over rough country, it is most desirable that whatever the exact configuration, it should be such that will permit in the lay-out practical provision for a minimum of uphill or indirect haulage, whether of thinnings, intermediate, or main crops.

If downhill and fairly direct haulage can be secured, and if the land is not too rough to plant regularly and systematically with reasonable facility and cost, there may not be any particular disadvantage in the situation being broken, undulating, or even somewhat hilly, and according to the general aspect and its inclination there may be distinct gains.

Trees love valleys and hillsides, and many species grow with a vigour and to dimensions under such conditions that they might not attain on level country, especially if the planted areas are small.

Valleys and undulations provide shelter as well as extra and more regular humidity, and the general configuration and inclination in some instances will lessen cost of haulage out of the forest.

Timber, being such a heavy commodity, and the cost of labour being so high in Australia and New Zealand anyway, the greatest possible facility in felling, preparing, and removing all forest material with as few changes as possible in the mode of transport, should be aimed at, and therefore configuration is a very important consideration in preparation and carrying out of the working plans.

Chapter XIX.

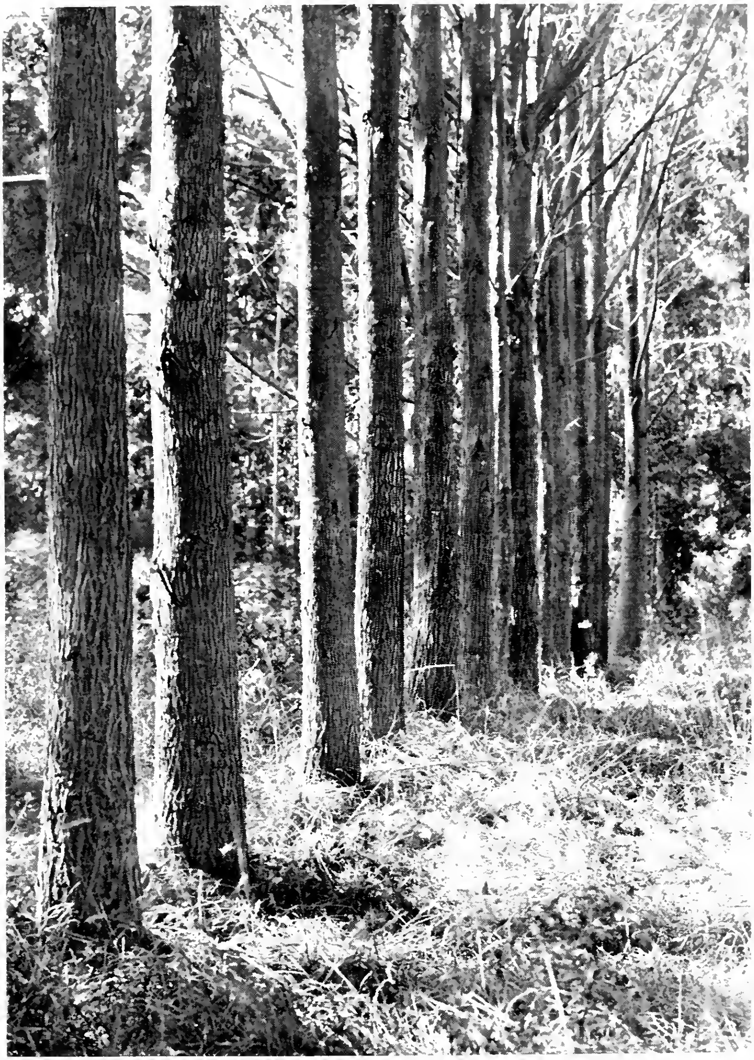
PURE AND MIXED STANDS.

As a rule the choice of both location and situation is made independently of the forester to whose lot it falls to carry out the work of afforestation. It might be assumed though that such should not be the case in connection with State afforestation, which supposedly would, from the very inception, be entirely under the best expert advice available, but unfortunately such is far from the real position, for political interference and lack of continuity of purpose, and also departmental dominance have unfortunately been the conditions pervading most State operations. At times those in control have lacked knowledge, or at best sufficient knowledge, at other times those nominally in control, though possibly possessing the requisite knowledge, are hampered in every direction—on the one hand by the vagaries of political inclination, on the other by the results of past blunders.

Locations have been selected which doom the undertakings to economic and financial failure, and so render futile the efforts of those in charge of operations. Or in some cases sound methods have been initiated, to be later ruined by neglect or incompetence, or by the choice of wrong location, making proper sylvicultural treatment impracticable.

In New Zealand much afforestation is being carried out by companies, and whilst in some cases location and situation have been carefully selected as necessarily precedent to successful operations, in other instances a thoughtless acceptance by the promoters of the State Forest Service ideas, as to location and system of planting, must result in the efforts of those in charge of operations, even if they are possessed of considerable or high qualifications, being largely discounted.

However, the forester, whether he has had an opportunity to influence the choice of the location and situation or not, has to apply his knowledge, ability, and skill in producing the greatest value of forest material at the lowest cost possible under the conditions obtaining. And not only is it his duty to do so for a period, but at the same time to aim at maintaining or creating conditions that will promote a continuance of high and successful production.



Taranaki plantation fifteen years old. *Eucalyptus* [illegible] 60 to 70 feet high, 18 to 22 inches in diameter. Originally mixed with wattle spaced four feet by four feet.

In the prosecution of these two aims are involved, of course, all the arts and practices of forestry—choice of species, selection of seed, selection of plants, decision as to whether "pure" or "mixed" planting, and as to the proportion of each species, kind of mixture, density, the times and extent of thinning, proper nursery, handling, etc., practices, general maintenance, protection against fire, disease, insects, and ensuring the building up of the forest floor and the maintenance and increasing of the fertility of the soil.

All these and more are involved in the growing of good timber in the greatest quantity quickly, but in addition, from the initial steps onward, there is the most important consideration of how the result—all forest material—can be put on the market at the lowest cost, for after all such is the real test of the soundness or otherwise of the undertaking.

Material, even of the highest quality, is valueless if inaccessible or if the cost of production and placing on the market is higher than the consumer can or will pay for it. And further, the production of material at a higher cost than necessary, even if the consumer can or is forced to pay that cost is economically unsound.

After the location has been decided upon and the requirements of the market judged, the first matter for decision by the forester in charge is the system of planting to be followed—whether "pure" or "mixed."

Pure planting has been the almost general practice in Australia and New Zealand, though possibly not quite to the same extent in South Africa for a period, but the tendency there is now much more towards "pure" planting.

In some earlier private and communal plantations, of rather small size, some haphazard mixtures were established—some as experiments, some for shelter, and others for beautification—but with the exception of a very little of the earlier planting by the New Zealand Forest Service, very little "mixed" planting for timber purposes has been carried out.

All the extensive planting for a long time by the New Zealand Forest Service has been "over open" and "**pure**," and with one exception, all the forestry companies in New Zealand are following the lead of the State Service both in "over open" and "pure" planting.

The position in Australia is much the same, but taking into consideration all the planting in South Africa a much less

proportionate extent has been "pure" and it is also less "open."

No doubt there were several contributing causes for such general adherence to "over open" and "pure" planting, important amongst which were doubtless the lack of any publications on Forestry applicable to these southern lands, and the lack of any recorded data having bearing on "mixed" planting.

To anyone who has a practical knowledge of forestry, afforestation under a system of "open spacing" in "pure" stand offers no serious problems in initiation or in care and maintenance so long as disease and other risks, and the yield of timber and its cost are ignored.

But a forester's duties go far beyond just that of growing trees. He has to aim at high yields, high grade, quick growth, lowest possible disease, insect, and fire risks, maintenance and improvement of soil fertility, and the putting the products on the market at low cost.

The programmes and statements put forward both by State services and others, and approved by supposed authorities, programmes of limitless areas of "over open" "pure stand" Pinus insignis (*radiata*) perpetually renewed, are enough to make any forester worthy of the name feel aghast.

Open spaced "pure" planting is the simplest possible thing in forestry, as it calls for little more than manual work under a "rule of thumb" system, so long as the important question of results is left out of consideration.

Probably one of the reasons why such practices have been so generally followed is that "mixed" planting is a very much more difficult and complex question than "pure" planting, and calls for much wider general knowledge of forestry, with very complete local knowledge, and a much higher degree of ability and skill in sylviculture. That such is the case would, in setting out the advantages and disadvantages of the two systems seem superficially one of the real disadvantages of "mixed" planting, but such should not for a moment be conceded as warrant for deciding the question. Timber, wood and wood products play such a vastly important and essential part in the economic life of practically every people, more particularly of the most advanced, that afforestation and all forestry activities deserve, and should have, the most able and highest skilled direction.

As we are dealing with afforestation in southern lands and have little to do with the many hardwood species of the

Northern Hemisphere, and further because of the enormously greater demand for softwoods, the question of continued healthy and satisfactory growing of a certain limited range of pines—all of which, in the case of each of our southern lands, are exotics—and certain Eucalypts, etc., is of the utmost importance, therefore it is a matter of prime importance that no course, such as extensive "pure" planting of exotic pines should be followed which might imperil this.

Dealing with the advantages and the disadvantages of each of the two systems, undoubtedly the greatest disadvantage by far of "pure" planting is the great accentuation of disease and insect risks. These are such very real and serious dangers that they alone ought to be the deciding factors in practically every case where any extensive afforestation operations, especially with pines, are contemplated.

The extensive planting of Pinus insignis in South Africa, considerable planting of pines, mostly insignis, in "pure stand" in Australia, and the planting in New Zealand of very large areas of "pure stand" insignis, and to a much lesser extent of other pines, in many plantations in close proximity to each other, all of which, being exotics and subject to various diseases and pests, in conjunction with almost entire neglect of seed selection, constitutes an exceedingly serious constant menace to the future production of softwoods in southern lands, the climatic conditions in which are so favourable to the spread of diseases and pests.

Whilst these species of conifers within the limits of their natural belt in northern latitudes of Europe and America continue to thrive generation after generation, their introduction into warmer parts, such as southern Europe and our southern lands, has been followed in some instances by disastrous attacks of various fungoid and insect pests.

There is the well-known widespread destruction that befel many conifer forests in Southern Europe, and the fate of "pure stands" of larch, and also the fate of the Scots pine and some of the Spruce in southern lands. Such experience should be, but apparently is not, sufficient warning against the wholesale invitation to disaster that general extensive "pure" planting constitutes.

In southern lands we are, so far, practically only dealing with first crops raised under virgin soil conditions, and even if these experienced, and continued to experience—which unfortunately is not the case—almost complete immunity, such

is no guarantee as to what will happen in the future, especially in the case of replanting.

Every authority points out that "pure" planting greatly increases the risks of fungoid and insect ravages, and that "mixed" planting is the greatest resister of such.

These risks may be lessened or increased to some extent by the seed used. Whether the planting is "pure" or "mixed" none but seed from specially selected trees—those of the very best type and showing continued vigorous healthy growth—growing under as near as possible similar conditions to those of the situation of the area to be planted, should be used.

Vigour of growth is not only important in resistance of diseases and pests, but also for the production of high grade timber and heavy yields. With very few, if any, exceptions, each species in a "mixed" stand, if the choice of species has been wise, will thrive better, generally much better, than if they were growing in "pure stand."

Sir William Schlich says, "Only a few species are fit to be grown in pure woods."

And quite recently there appeared in the English scientific journal *Nature* the following:—"The planting of pure blocks of rapidly growing exotics is in many parts of the world to court disaster in the long run in one form or another, more especially when the behaviour of the exotic from the sylvicultural point of view in its new environment is by no means well understood."*

Experience and all authoritative opinion is so conclusive of the unwisdom and of the grave risk taken in "pure" planting, especially of exotic pines, that the wholesale planting of very extensive blocks of "pure" Pinus insignis, especially in districts where numerous other similar extensive areas are being planted, is undoubtedly very distinctly courting disaster.

And experience in our southern lands has shown that few, if any, species grow to, or even nearly to, their full capacity in "pure" plantations.

Every tree in a "pure stand" makes the same description of demands on the soil and surroundings both in quality and manner, depth of roots, etc., therefore a "pure" stand is a most exacting crop and also, especially in the case of pines, a most exhausting one. While a plantation of mixed species, say of softwoods and hardwoods, if the mixture has been well chosen, is absolutely the opposite. The trees of the different

**Vide* note on page 149 as to freedom of Acacia Mollis from disease when grown in mixture with Eucalypts.

species have different root systems, and generally make different demands. In choosing the species to mix, the consideration of balance will always come in, shade, elimination of side branches, covering the forest floor, provision of humus, etc., etc.

Dense planting and many thinnings are essential to the production of high grade timber, but the early thinning, or even several thinnings, of some species, such as those of Pinus insignis, grown in "pure stand" are valueless, and nothing will add so seriously to the charge against a forest as the removal of large quantities of material to waste. On the other hand, in "mixed" planting, provision can be made for all the earlier thinnings to be of species, the material of which is valuable when young and of small dimensions, thus ensuring early and possibly exceedingly profitable returns.

Again, there are species which are costly to raise and plant in numbers, and which require much space to grow into big timber, but which are slow in growing when quite young and yet which if planted "pure" must be planted densely, and therefore are very costly for establishment, and yet the early thinnings of which would be practically valueless. If planted in "mixture" the costly trees for the final crop can be planted at their final spacing and the requisite density can be obtained by filling in with less costly plants, and such as would have value when young.

A tender species can, by being planted in "mixture" with hardier ones, be grown satisfactorily in situation where it would fail or be unsatisfactory in "pure stand."

Such as shallow-rooting species that either could not be grown in "pure" plantations, or that could not be thinned because of the danger of windfalls, can be planted with windfirm species.

Greater density can be obtained in "mixed stands" and a quicker and greater safety afforded against fire.

In case of "pure" planting failure of the one species through disease or any other cause means loss of the crop, whilst in "mixed stand" failure of one species may not be of serious consequence, especially if the remaining species is underplanted. Further in the case of "pure stand" the market for the timber of the one species planted may fail whilst in the case of a "mixed stand" loss may be averted.

Earlier returns, more frequent returns, heavier yields, less risk of disease, pests and fire, greater fertility of soil maintained, and a more diverse market can be supplied as a result of intensive afforestation in "mixed stands."

As stated earlier, it requires far greater knowledge and skill, and particularly local knowledge, because many species are very sensitive to local conditions, and therefore the fact that they thrive in certain localities is no guarantee that they will do so in others, and also, and this is most important, the rates of growth and the proportionate rates at different ages vary very greatly in different localities, and therefore besides a thorough general knowledge of the various species special knowledge of the effect of local influences is essential. Further the sylvicultural treatment is much more complicated.

But for the great risk of disease and insect pests, which cannot be ignored or evaded, and in the case of pines such as Insignis, soil exhaustion preventing continued cropping, "pure" planting for the sole purpose of supplying raw material for pulping and for the manufacture of wood products would have distinct advantages over "mixed" planting because, in view of the fact that the cost of raw material for such purposes delivered at the mill must be very low compared to that of ordinary timber, the cost of establishment and maintenance of "pure stands" is less than that of "mixed stands," and "pure stands" permit of clean cutting, which is essential to low cost of logging.

Reverting to the statement that few trees are suitable for planting in "pure stand" there has to be added the fact that some species will not grow to timber size in "pure stand," whilst if they are by single trees, or in groups, mixed with other suitable kinds they will develop to considerable dimensions. The Blackwood (*Acacia melanoxylon*) affords a marked instance. It is quite useless to attempt to grow Blackwood in "pure stand" for timber purposes.

Different types of mixture.—There are various types of "mixture." First of all permanent mixtures, that is, when it is intended to allow a number of each species in the mixture to grow to the end of the rotation. Second, temporary "mixture" where one or more species are acting in the nature of nurses to the main crop and are to be removed as thinnings. Third, when one species is planted and allowed to grow for a few years when another, quicker growing, is planted in between.

There is another, which really comes under the term "underplanting." This is such as where a light-demanding species has grown to considerable, or perhaps to full height, or nearly so, and it is deemed advisable for reasons, such as protecting the forest floor and reducing fire risks, etc., to

under-plant the light-demanding kind with a shade bearer. Such underplanting will foster the growth of the older crop, prevent soil deterioration, and make a fuller use of the area. Of this type underplanting Eucalypts with pines, for instance, has proved most satisfactory where there is ample moisture.

In either of the types there is no absolute bar to there being more than two species in the mixture, but certainly the second type, that where the species intended for the main crop having other species planted as nurses and so providing desirable density, facilitates a composition of three species, and permits the most intensive forestry, the best opportunity for maintaining and increasing soil fertility, reducing all risks and giving early and frequent returns.

Such a system of intensive forestry is not at all suitable for remote plantations, but is eminently so for suburban forests and those in closely settled country, and especially so for smaller plantations for private purposes. It is the type that requires most skill but offers the greatest advantages.

One of the greatest advantages of "mixed" planting over "pure," apart from its importance as a means of reducing risks, is that by its judicious application trees which in time might grow to great size and produce timber of very high quality, but which require an exceedingly long rotation period before they should be cut—too long a period if grown in "pure stand" to make financial success possible—can be grown as a small proportion of the mixture, the other species only being looked to as a means of making the undertaking profitable in the meantime.

For success in composition of a "mixture," whether permanent or temporary, whether second planting following a few years after the first, or an actual underplanting of grown trees, which latter might be termed reinforcement, of either a too thin foliaged or over-sparse stand, a thorough knowledge of the light-demanding and shade-bearing qualities of each, their requirements as to situation, and complete local knowledge of their relative rates of growth—both early and later—is essential, and further it is essential that the seed shall have been collected from specially selected trees, and on no account should it be mixed.

Many works on Forestry give much information as to what are good and what are unfavourable mixtures of various types, but such deal with species of trees grown in the particular country or countries in the Northern Hemisphere, and of which

the comparative rates of growth in different situations are known.

Unfortunately in our southern lands, through lack of sufficient data and the fact that the comparative rates of growth of many of the important species vary very greatly according to the varying conditions, it is impossible to give information as to composition of "mixtures," except to a very limited extent, that would be of any general value.

Whilst some species of those which we in southern lands must depend upon, such as Pinus insignis, are remarkably constant in their growth, being little affected by varying conditions either of climate, soil, or treatment, others are exceedingly sensitive to all such, and their comparative rates of growth, anyway of early growth, vary so astonishingly as to prevent the possibility, with the present lack of data, of giving them, failing local knowledge, any definite place in the association of species for purposes of deciding on composition of mixtures. Fortunately, what may be considered the standard species of trees for our southern lands—Insignis, Oregon, Redwood, Macrocarpa, and some other conifers, and many species of Eucalypts and some Wattles, can all be dealt with satisfactorily in "mixtures" of any type. This has been proved by demonstration to be beyond question so long as the rainfall, or the rainfall plus atmospheric and soil moisture, is ample.

But as approximately equal rates of growth, both when young and later, of all the species of which any mixture is composed are essential to success, notwithstanding that the different species dealt with are known to thrive well in association with each other, and as some species vary so greatly in their rates of growth in situations only a few miles apart, very full local knowledge is absolutely necessary in default of very exact complete knowledge of the special requirements and antipathies—climatic, soil, aspect, etc.—of each species. Unfortunately any little information that is now available is so meagre that it is entirely insufficient for more than pure generalization. However, presuming that the comparative rates of growth in the situation of the various species that it is proposed to use in the composition of any "mixed" planting, are known there are definite rules that must be observed in deciding on the composition.

1. If composed of two or more light demanding species they must be of equal rate of growth.

2. If of shade-bearing and light-demanding the latter must be the faster grower, but it is better that it should not be

very much faster. If the rate of growth of the shade-bearer and the light-demanding one is equal and the mixture is for some reason desired the best course is to plant the light-demanding one first, so that it may have sufficient start.

3. If the composition of a "mixed" plantation is to be of species that will not afford sufficient protection to the forest floor, underplanting with sufficiently shade-bearing species should be undertaken as early as circumstances will permit. The latter also applies in the case of "pure" planting with like species.

The degree of importance that should be attached in each case to the effect of the growing of any of the species, on the fertility of the soil, must depend upon several considerations, such as the value attached to the species, the quality of the soil, and the time that must elapse before underplanting can be carried out, or then the length of the rotation.

Chapter XX.

SEED SELECTION AND COLLECTION.

It is more than surprising that the question of seed selection, one of quite the most important matters in forestry, should have been so generally ignored as it has been, and that it should have received such exceedingly scant attention in works on Forestry. So scant, indeed, that work after work may be gone through without any, or practically any, reference to it being found.

Of course some reference is generally found as to the quality of seed, its germinating power, etc., but not as to its origin, the need for using none but that from selected trees, and the importance of not mixing.

Sir William Schlich makes more pointed reference under the heading of "Source," but passes by the question of heredity as one of which the importance is doubtful.

On the other hand, Mr. Maiden was much more definite, and stated that seed should not be collected from trees which are ill-shaped and not true to type.

It is possible that the absence or scant treatment of this matter in Forestry works is partly to be accounted for by the

fact that most of such works are founded on experience in the Northern Hemisphere, and that there the tendency towards variation of type in the case of the species of trees, there most considered in forestry, is not so great as, for instance, in Australia and New Zealand, though certainly not absent.

However, Mr. Maiden recognized the matter as one of importance in Australia, and the writer does not hesitate to assert, after long experience and special observation, that careful seed selection is a matter of utmost importance in afforestation—a vital essential precedent to full success in afforestation in southern lands.

The writer has on frequent occasions throughout many years pointed out how important careful seed selection was, and how generally its importance was ignored, even including State Forest Services. And yet, notwithstanding numerous examples throughout all our southern lands, especially in New Zealand, of the serious consequences in plantations, through neglect even to ensure trueness to species, let alone type, or desirable qualities or place of origin, tens of thousands of acres are being planted by State Forest Services and by many other organisations and individuals with trees raised from seed, much of it bought or collected under contract, collected from any and every tree good or bad, grown anywhere under any and every condition, and all mixed, quantity being the deciding factor, not quality.

It may be said that in some cases careful selection has been made, and undoubtedly that is quite true, and even in some cases care has been taken that the seed from each tree has been kept separate, but such cases are very few indeed, and in many, and probably most, cases where selection is claimed to have been carried out, certain plantations have been selected and either a collector sent or the collection of the seed has been let on contract to the owner of the plantation or someone else. Plantations in practically every case contain trees of various types and varying quality, from good to exceedingly ill-shaped and possibly ill-constituted trees. Such trees are not infrequently, or are in fact usually, prolific seed bearers, and the quantity of seed collected from these would outweigh by far that from the best class of trees, which are almost invariably very sparse seed bearers. The seed is all mixed, and the results of such cannot be other than exceedingly mixed.

Then there is the usual method of obtaining seed supplies, namely, just by purchase wherever procurable, either in large

quantities by contract or ordinary purchase from merchants or collectors, without any suggestion of selection or any knowledge or care as to origin, etc.

To some extent South Africa, it is understood, has not been quite so neglectful as Australia and New Zealand.

In an afforestation undertaking location and situation might both be all that could be desired, and the operation be directed by a thoroughly skilled forester, and yet his efforts might be so discounted, by the effects of neglect in selection of seed, to such an extent that what should have been a great success may be very far from it.

The following are the important points in selection and collection of seed:—

1. Seed from trees true to species, collected only from trees associated with others of their own species and type, or then only associated with those of other genera.
2. From trees true to type—many species have many different forms or varieties, varying more or less, sometimes greatly, in form, hardness, and quality of timber, and in rate of growth. The type that conforms best to the purpose aimed at should be selected, and trees of that type selected which are growing under conditions as described in the first instance.
3. From trees showing the most healthy, vigorous growth.
4. From the best grown, straight stemmed, least branched trees, though such may be bearing very little seed.
5. From such trees as described from a locality where the climatic conditions are nearest to those of the locality where the seed is to be grown.
6. Seed from different trees should not be mixed, even if it is all collected from good trees.

It may be difficult, or even in some cases, impossible to secure such a completely desirable selection, but it is certainly quite practicable if extra trouble and expense is gone to, to reach an approximate adherence to these conditions, for supply of seed for all important afforestation undertakings. And it should be the very first care of any State Forest Service, and above all such as undertakes the business of distribution of seed and plants, to search for and investigate reliable sources

of supply of such seed. All seed collection should be under absolutely reliable supervision.

As an indication of how important seed selection is, and in what ways and how seriously neglect operates, the following experiences are given:—

Seed was supplied by a State Forest Service on an order for *Eucalyptus gigantea*, and was so named, but when grown proved to be all *E. obliqua*.

Seed under name of *E. botryoides* was also supplied, and when grown proved to be of two distinct types of *botryoides* and a third less distinct, and also a considerable percentage of *E. saligna*. The result of this mixture of species and types is that one kind is outgrowing all the others, which are being suppressed, and the stand will consequently be so irregular and understocked that it will be of practically no value for the purpose for which it was planted.

E. botryoides plants supplied by a State Forest Service turned out to be of at least two very distinct forms of that species, and the consequences will be practically as bad as in the instance just mentioned.

Also from the same source Eucalyptus plants were obtained under the name of *obliqua* but they turned out to be a very general mixture of different forms of that species and several other distinct species including *E. eugenioides* and *E. regnans*. The planting was quite valueless, as no two trees are growing alike.

The same Service supplied plants under the name of *E. oreades*, which turned out to be *E. gigantea*.

Plants of *E. gigantea* were obtained from another source and practically all grew with double stems, whilst another lot were obtained from a State Service and proved to be all of a most perfect single, straight-stemmed type.

A block of *E. obliqua* eighteen years old, raised from seed carefully selected by the planter, made exceedingly rapid growth, and practically every one is absolutely ideal—perfectly straight, long clean boles with little or no taper. Whilst a block of the same species planted close by, under the same conditions, but raised from bought seed, has not one really good tree in the block. All are ill-shaped, much and heavily branched, but are all, but one, true to species. They are festooned with masses of seed, and whilst offering a rich "haul" to the seed collector, would spell disaster in any plantation where it was used.

There are numberless plantations of pines, especially so of insignis, with a general mixture of types. Some straight stemmed, lightly branched trees with excellent boles, others smoother barked, thinner stems, slower growing, but high quality, and others coarse heavily limbed, rank growing trees which will produce the poorest timber, but which are the dominating trees, and consequently suppress many of the others.

In practically every belt or block of Pinus muricata (Bishop's Pine) there is a general mixture of the two rough and smooth barked types. This mixture does not interfere with the growth of the trees, but whilst absolutely no benefit is gained by it there is the distinct disadvantage of a greater or less proportion of the stand consisting of the inferior smooth barked type.

The direct consequences of mixing seed, as for instance of pines, is that it results in trees of different types and different rates of growth, making it practically impossible to get an even stand, the result of which is heavy suppression that cannot be prevented by thinning, a proportion of heavily branched coarse timbered trees, numbers of partially dominated trees, and low yield.

With a "pure stand" of Eucalypts, or with many other trees, grown from selected seed, periodically thinned, means the nearest possible approach to a full-stocked stand of even sized boles, both in height and diameter, highest yield, and quality is assured.

In "mixed" planting, properly selected seed is of much more importance than in "pure" planting, for however complete the forester's knowledge may be he cannot anticipate the effects, nor can he rectify the unsatisfactory conditions brought about through a mixture of seed including different types or wrong species, or through the seed belonging wholly to a different species or type from that upon which the selection of the species for composition of the mixture was based. A certain rate of height growth and density or sparseness of foliage would be relied on, and if either of the kinds composing the mixture proved to be of a different species or type from that intended and of slower growth or greater or less degree of shade giving, the stand might be destroyed, or at the best prove seriously faulty.

An actual experience of a "mixed stand" composed of two species planted in alternate rows was as follows:—The one species proved to be a very short-growing umbrageous type. For some time conditions seemed satisfactory, but later the

one species composing every alternate row grew right ahead of the other, and instead of its branches being suppressed until nearly full height, they spread out in the form of heavy limbs right over the top of the alternate rows with disastrous results. Whilst in another case a mixture composed of the same two species but of correct type resulted in long clean straight boles in both species.

The astonishing thing is that so obvious a matter as the great importance of careful seed selection should have been so generally ignored, and especially that it should have been ignored by State Forest Services, which are spending great sums in afforestation, and which are widely distributing seeds and plants.

The great importance of having good stock from which to raise our horses, cattle, and sheep is fully recognized, but apparently it is thought any distorted, disease-ridden scrub of a tree is good enough to grow our forests from.

Chapter XXI.

NURSERY.

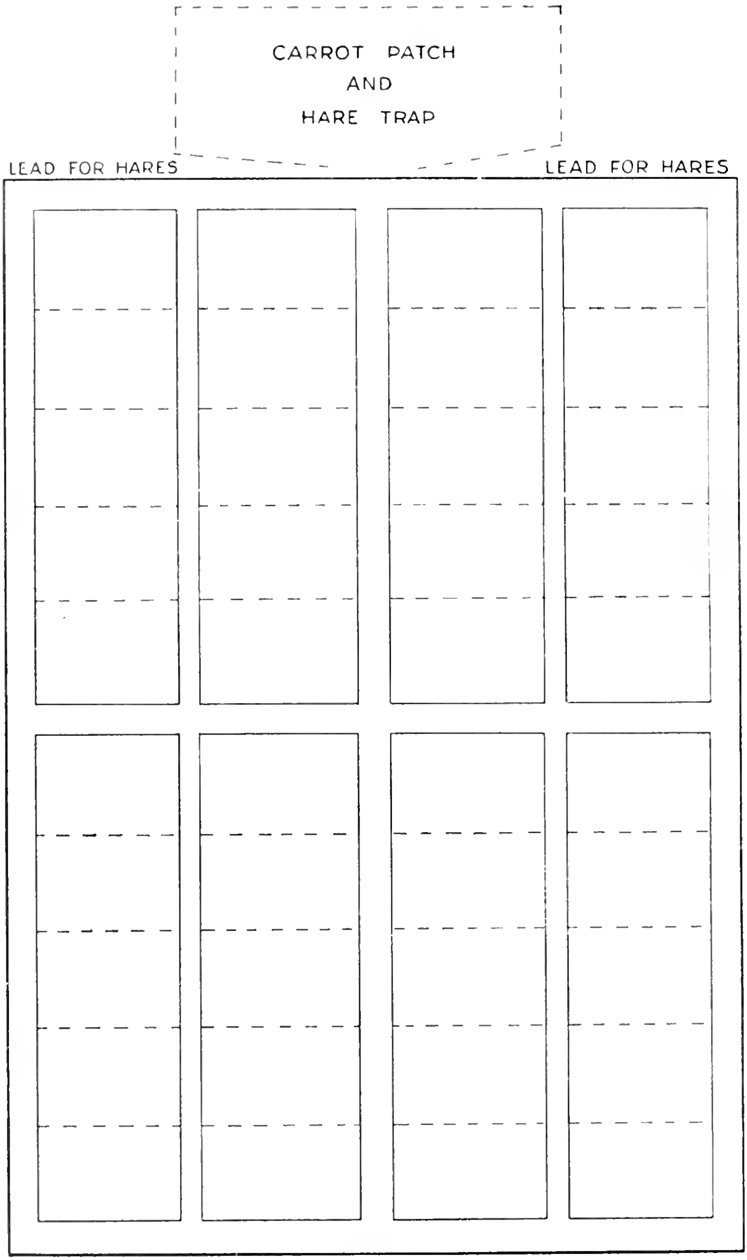
There is no need here to go into any very fully detailed description of nursery practices, as whatever lack of recognition there may be as to the importance of expert knowledge and skill in forestry, at least the forest nursery work is likely to be carried on under experienced nurserymen. Also in each country, and even in different districts, special methods are followed, usually based on soil and climatic conditions, and the species to be raised.

Also much depends upon the extent of the operations for which the plants have to be raised, and whether most of the planting out will be done with plants taken direct from the seed rows or with plants which have been transplanted.

Site.—The site of the nursery should be as nearly as possible central to, or most easily accessible to, the greater area to be planted as the quality of the soil and configuration of the land will permit.

But it is more important than the best accessibility that the soil should, if possible, be a sandy loam, friable to some

PLAN I



SUGGESTED LAY-OUT FOR A NURSERY

depth, fertile, and neither too wet or too dry, and well drained. It is not necessary that it should be quite level, but should be nearly so, and nowhere should have so great an inclination as to render the finely worked soil liable to be washed off by heavy rains. It should be sufficiently sheltered to prevent injury to seedlings by winds, but not so much as to affect their hardiness.

Frost-beds should always be avoided. Deep, sufficiently porous, well drained soil, not in a depression but rather relatively higher, with in colder districts preferably a slight inclination to the sun, should secure a lesser danger from severe frosts than the country generally would be subject to. Such a site should ensure good germination, quick sturdy growth, and a long growing season.

But choice of situation must almost entirely depend upon an experienced nurseryman with local knowledge, and therefore any indication given here must be treated as purely general.

The lay-out of the nursery should be such as to most fully facilitate all operations—use of implements, removal of stock, drainage, irrigation, fallowing, etc.

Seed beds.—The deeper ploughed and the more thoroughly and deeply worked, and the more thoroughly freed from weeds the soil has been in preparation for seed sowing the better.

The degree of firmness most beneficial will depend upon the soil and subsoil, the climate, and the season of the year. But where the soil is friable and loose, rolling before and after sowing will probably be advantageous, even if not absolutely necessary.

Fertilizers.—Fertilizers most suitable to the species in the particular soil may be used, and are generally beneficial both when sowing and transplanting, but farm-yard, green, and other natural manures should only be used in preparation or when fallowing, and should be thoroughly and deeply buried.

Rotation.—It is of much importance that a system of continuous rotation should be practised. No plot, if circumstances permit, should be used two seasons running for raising the same class of seedlings or for lining-out the same class of plants. Plots that are used one season for raising seedlings or growing plants of Acacia should be used for Pines or Eucalypts the next.

Seed selection.—Special reference has been made elsewhere to the extreme importance of all seed being gathered from

especially selected trees, of the right type, and growing under, as nearly as possible the same climatic conditions as those of the locality in which the seed is to be grown, also that seed should not be mixed. If this course is followed both the raising of good uniform plants in the nursery and the raising of a satisfactory plantation will be greatly facilitated.

Treatment of Seed.—Wattle seed, before sowing, requires a thorough soaking in hot water. If boiling water is poured over the seed and it is left to stand for a day or even three or four days—the older the seed the longer the time required—the germination will be satisfactory. It has been proved that Wattle seed can be boiled for even fifteen minutes without its germinating power being destroyed.

Pine and Wattle seeds should be deeply covered, especially if the soil is inclined to be loose, but Eucalyptus seed should be sown on a rolled or firmed surface and rather lightly covered and then rolled or firmed by other means, but anything in the nature of beating, such as with the back of a spade, should on no account be done, because almost all Eucalyptus seed is so light that it is easily widely spread by any such action.

Seed rows.— The usual tendency in nurseries has been towards too wide seed rows, such as from ten up to even fourteen inches wide or more.

The result of wide rows unless extremely sparsely occupied, especially with seedlings that grow to some considerable height before being removed, is that none of the seedlings get a fair chance of balanced growth. A few of the outside ones and a few of the most vigorous grow rapidly ahead of the rest—which probably are 95% of the whole number—and add the disadvantage of overhead shade to that of massed growth, resulting in weakened, spindly plants, most of which are quite unfit for use.

Though much more room, more labour, and more covering, where such is needed, is required in the case of narrow seed rows, such can hardly be too narrow so far as the seedlings are concerned.

Quite narrow seed rows—say 2 or 3 inches—carefully sown so that the seed is fairly evenly and openly distributed along the rows, will give infinitely better results in every way than can be obtained from broad rows. The plants will be sturdy, short, thick stemmed, well rooted, and even in size and quality.

They are easier to wrench, can be used younger, and when lifted are easier to grade with a minimum of rejects.

To produce that class of seedling, whether required for direct removal to the plantation or for transplanting in the nursery, should be the aim of the nurseryman. Such plants will always give satisfaction, and if properly handled and carefully planted, should result in even fully stocked plantations.

Distance between rows.—The distance between seed-rows should be at least a foot, better more, to give room for hand-hoeing and wrenching, and greater still if a hoeing or cultivating implement is to be used.

Covering of seed rows.—In many places birds and mice, but especially birds, are so destructive in the seed rows of many seeds, such as that of Pines and even Wattle, from the time that the seed is sown until the seedlings are well rooted, that it is quite necessary to thoroughly protect them.

The trouble and cost, especially with narrow rows, may seem considerable, but in many places only with proper protection can satisfactory results be ensured.

Actual experience has shown that where rows and parts of rows have been properly protected and other rows and other parts of the rows have been left unprotected highly satisfactory results have been obtained in the first case whilst practically not a seedling has survived in the latter. Very light gauge fine mesh wire netting of sufficient width to allow of it being bent in a form that will cover the row, giving plenty of room and allow the edges to be pegged close into the soil on both sides, is suitable.

The netting should be cut a foot or more longer than the rows and bent into regular shape over, say, a piece of timber 8 or 10 inches wide, as the width of the top, the sides about 4 to 8 inches deep sharply bent down, but with a slight spread, and the ends turned also, so as to allow of the whole being pegged down over the seed row in a manner to prevent the entry of the smallest bird. In such form the lengths will cover the rows thoroughly, and will be sufficiently stiff to permit of handling by two people without damage. They can be moved from one set of rows to another to serve successive sowings, and when not in use can be stored packed one inside another.

In very large nurseries birds may be kept away by boys with guns, but the watch must be continuous from first dawn

until dark, but such will be no protection against mice, hares, or rabbits.

The seed beds for raising of some species, such as Redwood, require covering with scrim-covered frames until the seedlings are quite strong.

Wrenching.—This work should be carried out as far as possible in moist weather, and not at all during drying winds. If the weather conditions are favourable both sides can be wrenched at once—a man working on each side of the row—but if not quite favourable only one side should be done at a time and extra care taken in firming with the feet after wrenching. Spades used for this purpose should be keenly sharpened, and the cut should be clean and under and beyond the middle of the row, so that when both sides are done no deep roots will have escaped severance. The inclination of the cut, in other words the depth, must necessarily be in accordance with the size of the plants, care being taken, after a trial cut and examination, that the cuts are not made too shallow or too deeply.

The wrenching of seedlings is a much more simple business than that of transplanted plants, but its thoroughness is essential to full or even fair success of the latter operation.

If the operations are on an extensive scale the wrenching can be done with a wrenching implement, which if of a good type, blade kept keen, and operated with care, will give satisfactory results.

Where it is intended to use cultivating and wrenching implements the beds should be made long, and the rows spaced sufficiently widely.

Removal and Grading.—When sufficient time has been allowed after thorough wrenching—that will be, when, on lifting the plants, young white shoots show freely on the roots—the plants should be taken up and graded into two or even three grades, poor plants being rejected altogether. When grading the quality and not only the size should be taken into account. Sturdy thick stemmed short plants with good roots should be chosen in preference to spindly, thin stemmed though taller ones, and plants with numerous fibrous roots in preference to those with few wiry roots.

When graded the plants should be counted, all over-long or loose roots being cut off with a sharp knife, as they are placed in bundles of equal numbers, either to be damped, tied up, and mossed, or puddled in mud, ready to be taken out to

the plantation, or then, the grades being kept separate, heeled in thickly in rows of equal numbers in readiness to be taken out and made up for removal to the plantation. Second and third grade plants, or any plants that are not going to be planted out as seedlings should be heeled in thickly temporarily to be lined-out in the nursery later. Such lines should be at least twelve inches apart, and wider if hoeing or cultivating implements are to be used.

Seedling plants, according to species and class, should be 2 or 3 to 6 or 8 inches apart in the rows. Second or third year old transplants should be more widely spaced both as to rows and intervals in the rows.

There are many methods of planting the plants in the rows, possibly the most usual and simple is that of making a V-shaped trench, one side upright of ample depth to permit of the seedling being placed in it upright without bending up any of the roots. This method ensures the plants having all their roots well spread without any bending or doubling back.

The numbering is necessary first, so that the numbers required from time to time to be sent out to the plantation can be assembled without disturbing the plants for counting them, and next so that stock on hand will be accurately known.

Narrow seed rows and sparse sowing favours direct removal from the seed bed to the plantation.

Keeping plants moist and covered.—It is most essential, and especially so with Eucalypts and Wattles, that during all these operations of lifting, grading, counting, trimming, heeling-in, lining-out, removal to the plantation, etc., the plants should on no account be exposed to drying winds or unduly to the sun. They should never be allowed to dry, in fact, should be kept moist and covered as much as practicable. Grading, counting, trimming, and packing of Eucalypts, Wattles, and all seedlings can best be done on benches under cover.

Hares.—Hares are, in some districts, a very great trouble in nurseries, causing much damage by scampering over the seed beds, disturbing the seed and very young seedlings, and they are a source of great trouble and loss in the young plantation. If the nursery is more than a purely temporary one it is certainly advisable to surround it with suitable wire netting. It is well every season to put in a plot of carrots in a corner of or near the nursery to attract the hares, where they can be easily trapped.

Chapter XXII.

PLANTING.

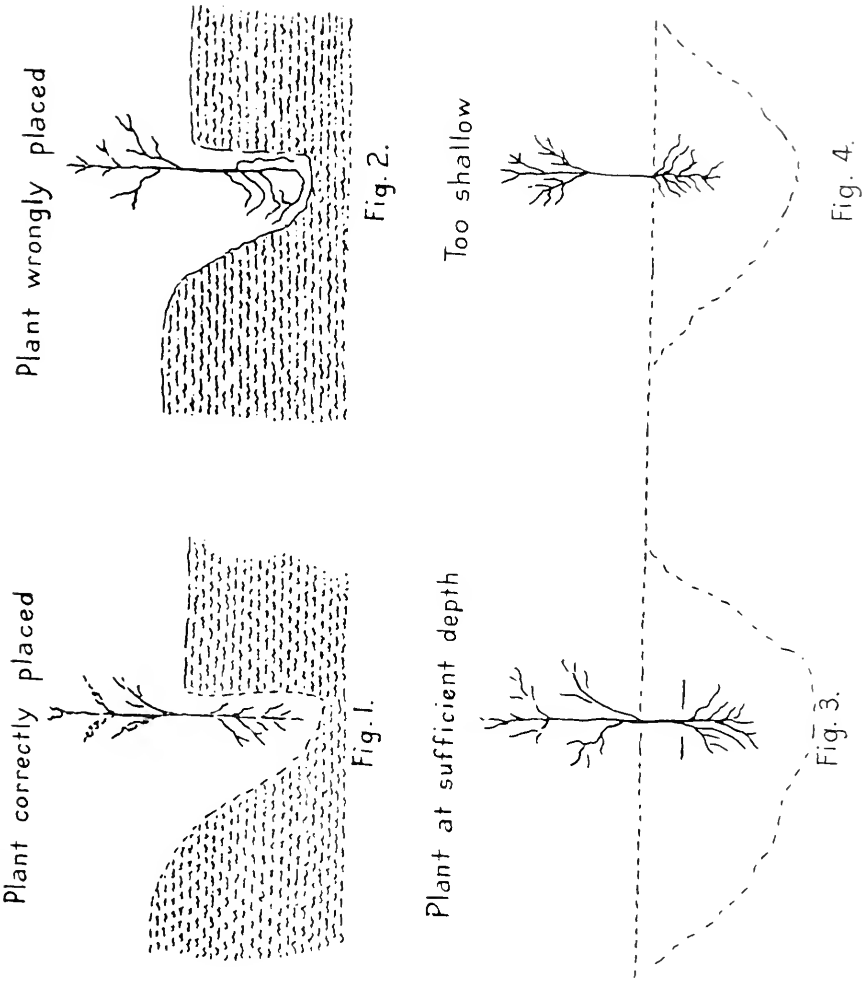
Roots.—Other conditions being favourable the growth of a tree, when young, and more particularly when older, will depend upon its rooting system. If the roots are well spread and nowhere cramped, twisted, or crossed, a tree will, other things being favourable, continue to thrive and grow vigorously throughout the natural growing period of its species. If the roots are cramped, or matted, or twisted, or crossed, the tree may grow seemingly quite well when young, but sooner or later, and certainly before it attains dimensions of value, it will lose health, cease vigorous growth, and will ultimately come down, probably during a gale, injuring others and encumbering the forest.

Trees grown in the forest direct from seed, if proper thinning operations are carried out, are assured of as good a rooting system as the soil conditions will permit. It is in transplanting in the nursery and planting out in the plantation that so much harm is done. In both these operations the greatest care should be taken to ensure that no roots are unduly pressed together, and that none are turned up, twisted, bent, or crossed when being planted, hardly any greater sin than such treatment can be committed in connection with forestry or any tree planting operations, for the crime is hidden, and if committed in the plantation may not be exposed for ten or even twenty or more years, and therefore is absolutely beyond correction.

If the condition of plants when lifted is such as to make planting, without improper placing of the roots difficult, it is far better to run the risk, by over free use of the knife, of a proportion of the plants dying when planted out, but which can be replaced, than to plant and grow young trees for some years which are doomed to ultimate failure.

Quality of Plants.—The importance cannot be too strongly stressed of the need of especial care as to selection of seed, the quality of the seedlings used, and proper planting.

The cost may be greater, but what is the extra cost even of £1 per acre say against the inevitable loss resulting from carelessness or neglect?


Plant correctly placed
Fig. 1.
Plant wrongly placed
Fig. 2.
Plant at sufficient depth
Fig. 3.
Too shallow
Fig. 4.

Only by special care in these directions can a fully stocked, healthy, even grown stand, wind-firm at all periods, be ensured.

Depth at which to Plant.—Next to the care of the roots in planting comes the question of depth and firmness. The usual thing one sees and hears about the depth at which to plant is the placing of the plants at the same depth or slightly deeper than they stood in the nursery, without regard being paid to the climatic or soil conditions.

Time after time the same advice is repeated in almost identical terms, without qualification as to the nature of the soil, the climate, or the class or size of the plants. It appears in nurserymen's catalogues, notes on Forestry, and even in works on Forestry.

Such a method may answer with fruit and ornamental trees and such like planting, where much individual care and attention can be given, and where there is usually considerable shelter, but for the establishment of a plantation it is very far from good advice. At least that is the distinct opinion of the writer.

Of course, where the soil is very stiff and adhesive, and such as when firmed will exclude the light and air, it will be necessary to place the plants at a depth very little below that at which they stood in the nursery, but when the soil is sandy or friable, and especially when it has been ploughed in preparation for planting and where dry conditions have to be contended with, deep planting is most important, usually much deeper than they stood in the nursery.

Planting.—Except where the soil is very sandy or of a loose pumicy nature where the weed growth will be negligible, or where the land has been ploughed, it is advisable to dig out a large sod, replacing it upside down, chop it thoroughly up and firm the soil before making the opening for the plant. The split with the spade, notch or other opening should be so ample for the size of the plant used as to permit of it being set deeply in the opening without doubling or cramping any of the roots. It is advisable when putting the plant in to first place it considerably deeper than required and then draw it up slightly so as to ensure that all roots are freed.

When firming the plant the heel of the boot should be driven in heavily towards the plant but some few inches away from it, so that the roots at the bottom will be properly firmed but the soil around the stem be left loose so that light and air will get to the stem that is below the surface. This loose surface

will later naturally compact somewhat, and the seedling or young plant will be occupying a depression.

The effect of carrying out this system of deep setting and firming at the bottom and not at the top is (1) that all the part of the plant below the crown—the roots—is in close firm contact with the soil, and the surrounding soil is properly consolidated, (2) the young plant, being deeper sunk, is very considerably sheltered, much of the stem is protected from the sun and wind, (3) the roots and lower part of the stem are kept in a more even condition of moisture, and (4) any movement caused by the wind is distributed along the stem and cushioned against the loose earth instead of being all at the junction of the roots, disturbing them and letting the dry air into them. The whole of the soil on the surface being left quite loose permits ample light and air to reach the covered portion of the stem, and so prevents injury to it by suffocation, it also ensures that any undue opening around the stem due to movement by the wind will quickly be filled by the fine loose soil.

This method of deep planting of forest plants, firming at the bottom and leaving the surface loose, is not in accordance with general practice, and is contrary to usual direction, but it has been practised by the writer during a great number of years with very highly satisfactory results. All the planting in the plantations of the Taranaki Forestry Company, near New Plymouth, New Zealand, has been carried out by the direction of the writer under this method, though much against the inclination of some associated with the carrying out of the work, and it has proved most eminently successful, the percentage of successful "takes" (excluding some later loss by hares, etc.) and the vigour of the young trees, and the extraordinary rates of growth are most remarkable, and probably unexcelled in any plantations in New Zealand.

Experience has proved that a maximum of success in establishment and rapid early growth is obtainable from such a system of deep planting wherever practised wherever the nature of the soil is not too stiff.

The person in charge of a planting team should, from time to time, go along some of the rows of each planter and test the firmness of the plants by taking hold of the plant and giving it a good pull. Should any plant give way the planter responsible should be checked and warned that any recurrence cannot be passed.

Anyone fit to be in charge of a planting gang should know the strength of pull any class of plant should withstand. If plants give to a proper pull it is clear that the soil has not been driven in by the foot of the planter, or by other means of firming, to firm the roots sufficiently, and if carried on the percentage of misses will be unduly high.

If the seed has been well selected, the plants raised in narrow rows so that they are thick stemmed, sturdy, well-rooted plants, and if they have been properly wrenched, graded, and handled, always kept damp, and have been carefully, deeply, and firmly planted in situations suitably prepared there should be practically no misses except when unexpected extremely drying winds occur before they are established, or where destroyed by hares or other pests, or by weed growth.

Replacing.—However on occasions some losses will occur, and as a fully stocked even stand is most important all failures should be made good with extra strong advanced plants, planted with especial care as early as possible.

All replacing should be carried out within the twelve months in which the main planting was performed. If it can be done at the latter end of the same season all the better, but if it cannot then it should be done during the very first weather fit for planting at the beginning of the next.

Cleaning and Weeding.—In some situations, especially where weed growth is not troublesome, sturdy well-rooted plants will make such progress that they will quite outgrow the weeds, but in other cases clearing back of weeds with hooks, or in the case of some species actual weeding with hoes, will be necessary to prevent injury or complete suppression by the weeds.

Weedings or cleanings are the most costly and troublesome single operations in connection with establishment, but if required must on no consideration be neglected, for neglect would mean a much understocked uneven stand that no future work could properly remedy, and low yield and poor grade timber would result, besides which the fire risks would be very much increased.

It is clear that it is most important that care should be taken, in the first instance, to establish a plantation with nothing but the most forward, sturdy, best grade plants.

The cost and trouble of cleaning, and the risk of suppression are matters so important that they should be given very full

consideration by the forester when selecting the species to be planted in any particular situation.

The forester should see that everything possible, within reason, is done to ensure the highest percentage of success, and such rapid growth of the young plants as will place them beyond injury by weeds as quickly as possible.

Chapter XXIII.

FULLY STOCKED STANDS.

A fully stocked and even "stand," whether it is "pure" or "mixed," is of great importance, for by such means only, presuming that the spacing has been sufficiently close and that proper thinning is carried out, can a high percentage of high grade timber and heavy yields be obtained.

To succeed in raising such a stand, not only is the art and skill of the forester required in sylvicultural treatment, but the species must be well chosen to suit the situation, and the seed used carefully selected and unmixed so as to ensure as even growth as possible.

The selection of seed, careful planting, and the checking of all ranker growing plants will prevent what is so often seen in plantations, namely, a small proportion of dominating trees unduly retarding the growth of a much greater number, with the inevitable result in heavy suppression, followed by an irregular understocked stand in which the ranker growing trees, which will produce low grade timber, form the bulk of the crop.

On the other hand, if such conditions are prevented in early growth, thinning from time to time, at proper times and to the proper extent will promote steady even growth throughout.

Whilst all distinctly faulty and weak plants or trees should be removed, the aim should be to promote even growth of all and not to sacrifice or allow to be sacrificed those plants which are slightly backward to those inclined to be dominant.

Selection thinning, by the removal of all but the most vigorous, and retaining all the larger trees, whilst approved by some and claimed to result in larger yields, possibly suitable in certain classes of plantation and in dealing with the species

of trees grown in the Northern Hemisphere, should not be practised in properly established plantations of species which it is advisable to grow in our southern lands. But it may be the only thing to be done in cases where plantations have been badly established, or where good establishment has been followed by prolonged neglect.

If a plantation has been established upon a plan designed with the object of carrying out regular systematic thinning, and not selection thinning, such thinning can be quite satisfactorily carried out in a "mixed stand" or in a "pure stand" of Eucalypts or Wattles, but in a "pure stand" of pines the matter will be more difficult, as anything other than a slight thinning would tend to open the canopy too much.

In establishing a "mixed stand" the trees which are planted to act as nurses to those of later crops, and are to be thinned out first, should be of a sparser foliaged species, otherwise their early removal may open the canopy so as to expose the forest floor unduly and cause a check in growth and other harm.

Constant even degree of humidity and shade are essential to rapid growth, and to the production of good quality, even, fine-grained timber. To quote Professor Curtis—" . . . it is necessary in the development of timber to secure uniform and level growth. Throughout the forester should endeavour to obtain an unbroken leafy canopy, and this he cannot obtain if trees are of irregular growth. True forestry greatly consists of uniform and regular growth, this gradual and even development of timber, this mutual dependence on each other for support."

Besides the very important effect on the growth of the trees, the quality of the timber, and the yield that the condition of the stand has, a fully stocked stand is the greatest possible safeguard against fire.

Any weak places or what may be termed "pockets" permit of a much continued growth of weeds, etc., and a development of large spreading side branches which later die or partially die, which together with the dead undergrowth make a mass of inflammable material extending from the forest floor to the crowns. All such places are a continuous menace. In any one of them a fire may be started, and in a wind, even when the forest floor is damp, become a "crown fire." Or on the other hand a ground fire that might be quite harmless or smouldering for a long time, giving ample time for discovery and

extinction provided the "stand" was fully stocked, might if "pockets" existed reach one of them before discovery and cause a disastrous "crown fire."

Further, if a "stand" is fully stocked the forest floor and the boles will be clear of all growth and encumbrances, and passage through in all parts and all operations in the forest will be clear and unimpeded.

Chapter XXIV.

PREPARATION OF LAND AND LAY-OUT FOR PLANTING.

Weeding and cleaning are two of the most costly single operations in establishing a plantation, therefore for that reason, apart from others, rapid early growth is of great importance.

A fully stocked stand is essential to reduce the fire risk and for the production of high grade timber.

Regular systematic planting greatly assists in ensuring a fully stocked stand, facilitates all operations in the forest, greatly that of thinning, and especially that of felling and logging.

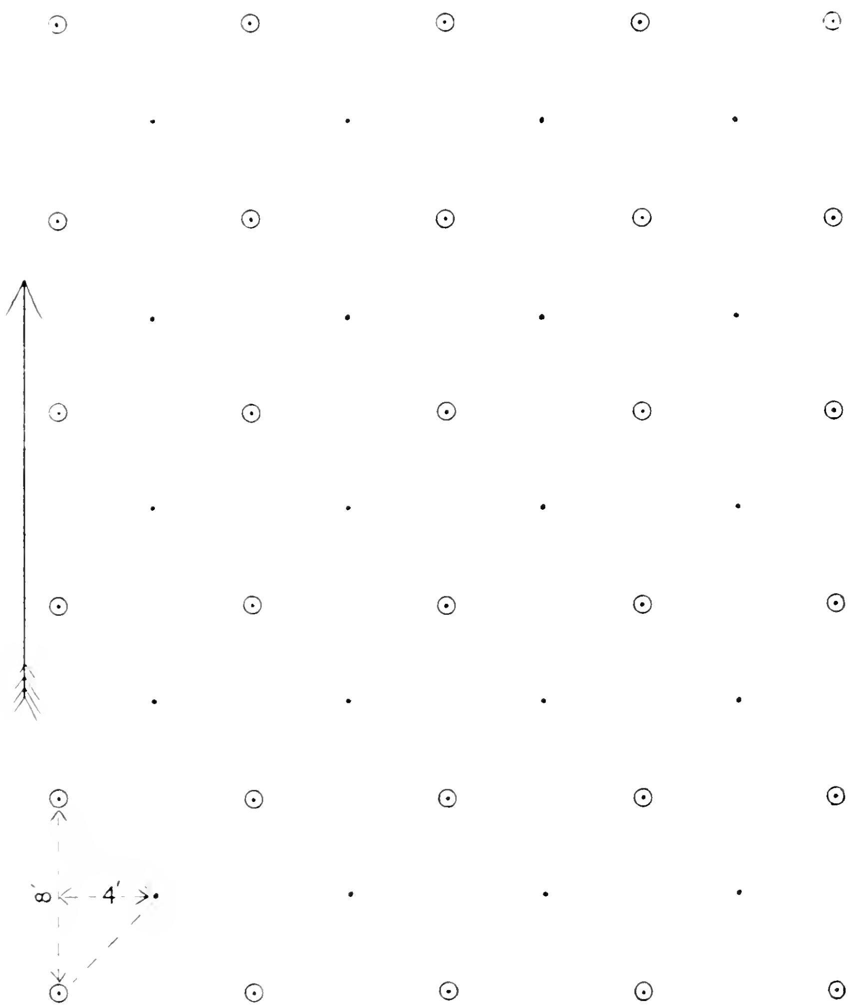
For several years after establishment, until the canopy is complete, the fire risk is very great, and therefore that should be guarded against in every way.

For the foregoing reasons it is important that as a preliminary to planting, the area to be planted should be cleared and prepared to the fullest extent practicable. There are some classes of country, such as some poor, or sandy, or pumice land, where weed or other growth is very sparse and short, and where the soil is sufficiently free to need no, or practically no preparation, or from which no adequate advantage could be gained by any preparation. But where there is any considerable scrub growth of any sort, even if it is sparse, and only a few feet high, it will usually be advisable to clear it off by burning, if it will burn without cutting, or then by cutting and burning.

Many planters, under advice, have followed a plan of planting direct in amongst scrub growth three or more feet

PLAN 2

ALTERNATE DOUBLE SPACING



The most desirable system of spacing.

high, either without any clearing whatever or then just the cutting of narrow lines. The New Zealand Forest Service has followed this practice, at least at times, and has recommended planting companies and others to follow it. There are many instances of disastrous results of such a practice.

There may, in rare instances, be extraordinary circumstances, such as extreme exposure, where such a practice may be advisable, but as a general practice it deserves nothing but utter condemnation.

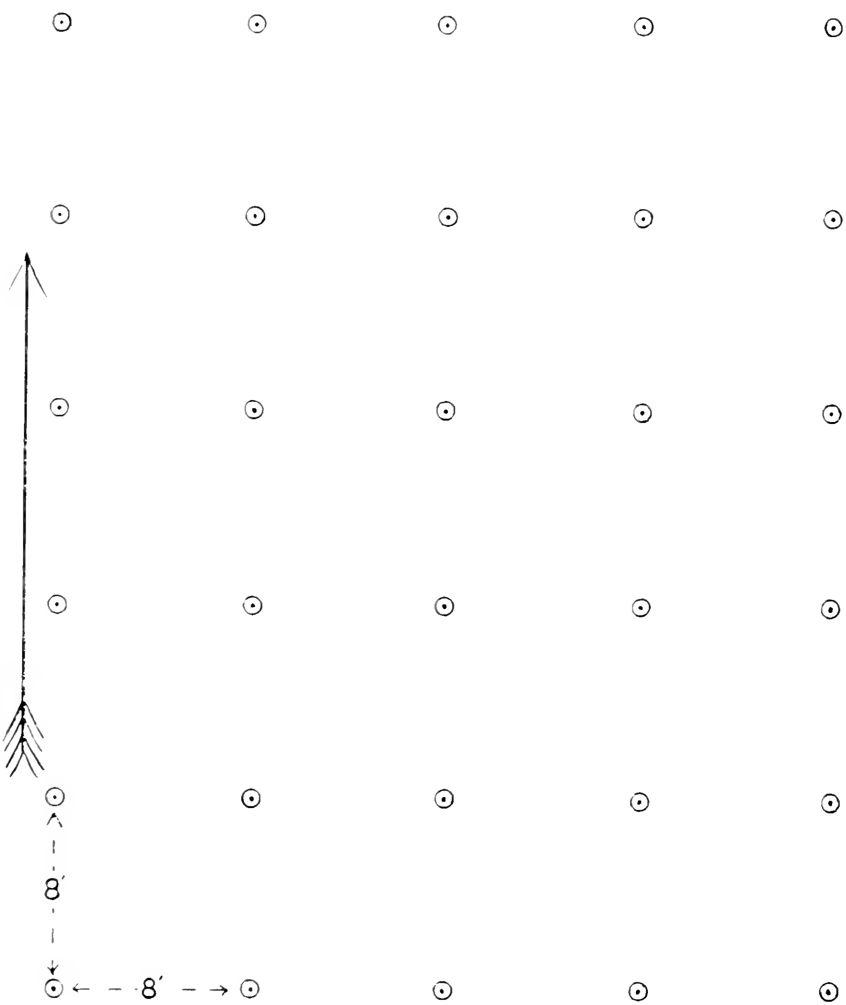
First, it is hardly possible to lay off and keep the planting in systematic regularity. Secondly, anything like full replacement is practically impossible. Next, for various reasons, such as variation of degree of shelter and shade, the growth will be most irregular, and ultimately the stand will be irregular and far from fully stocked. And lastly, and what is more serious than all else, the fire risk will be enormous. Whilst the plantation is young and a canopy has not been formed the young trees will be surrounded and in places topped by the scrub, offering a continuous risk of destruction by fire, and later when the canopy is formed all the scrub will be killed, but will for years be held up by the branches of the trees, providing a mass of exceedingly inflammable material—an enormous menace. Further, the presence of this material greatly encumbers any operation in, or inspection of, the forest.

Of course the degree of clearing and other preparation that is practicable will much depend upon the configuration and the condition of the country. Steep rough country or that with an excess of logs and stumps can have little else done to it than cutting and burning.

Advantage of Ploughing.—Unless the trees that are to be planted are of the quickest and hardiest species, such as Pinus insignis, and large plants are to be used that will grow well on unploughed land, all places that can be ploughed and harrowed should be so treated. With perhaps the only exception of Pinus insignis, all species will grow whilst young better, in most cases very much better, in cultivated soil.

Smaller plants can be used with much advantage, they can be better planted, more regularly planted, and they will start and keep growing much more rapidly. There will be fewer misses, and these easier to see and replace, and such weeding and cleaning as may be necessary—the fact of rapid growth will greatly lessen such—will be much easier to do.

PLAN 3



Complete clearance and cultivation of the land permits of much greater facility in regular and systematic lay-out for planting.

Lay-out.—If the land is level or nearly so the whole matter is quite simple. The position of any roads and the position, distance apart, and width of the fire-breaks, having been decided upon, the planting lines will be laid off at right angles to these.

On the other hand, if the country is considerably undulating or hilly the matter is less simple. Such roads as might be required would have to be so laid off as to be of fairly easy and even gradient, and the fire-breaks wherever they would be most effective, and the hauling tracks where they would give the easiest exit whilst providing for a minimum of uphill and a maximum of downhill haulage.

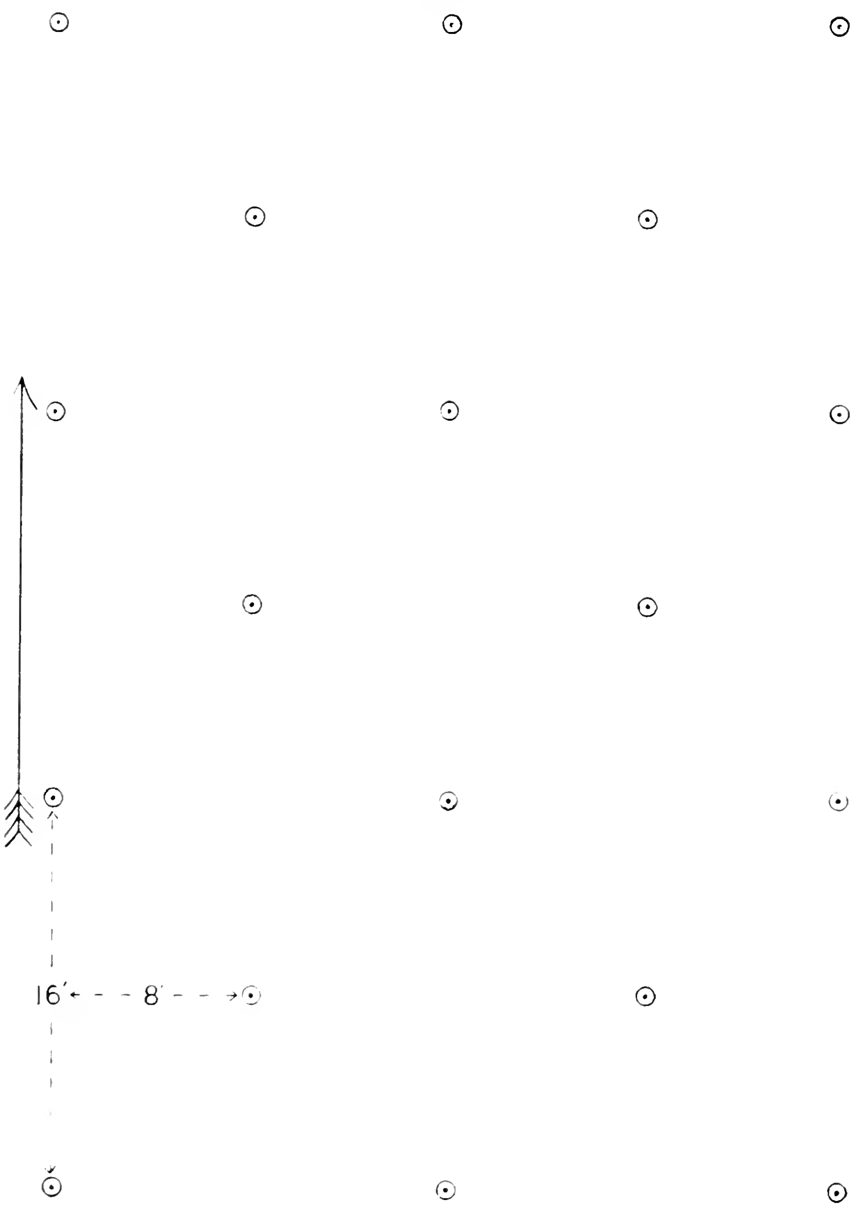
The planting lines should be laid off so as to be as nearly as possible directly up and down hill from the hauling tracks, altering direction as the configuration of the land necessitates.

In the case of "pure" plantations where the whole crop is to be cut at once, as for instance if grown for wood for manufacture of pulp, the direction of the lines or the exact regularity of the planting is of little consequence, but in all cases where thinning is to take place, and especially where the plantation is "mixed," regularity and the direction of the lines both of which immensely facilitates the felling and removal of all thinnings and intermediate cuttings, are of great importance.

Plan 2 displays an alternate double spacing system of spacing, where the distance between the trees in the rows is twice that of the distance between the rows. Planting "on the square" is almost general in practice, and in "over open" spacing, where it is not intended to thin, especially in "pure" planting, there is nothing to be said against it, but in "close" and in "mixed" planting, where intensive forestry is to be practised, the alternate double spacing system as shown in Plan 2 is preferable.

Far the greater number of the trees planted are removed by thinnings in the earlier years, and the forester when deciding on the composition of the mixture should see that at least the greater number of those to be early removed are of a species that will provide material of value when young, and therefore should so plant them as to facilitate felling and removal, as it is imperative that the costs of handling all

PLAN 4



material, especially material of low value, must be kept at the minimum. Any difficulty in felling so as not to injure the remaining trees, or in removing from an awkward position, would increase the costs of handling many times over. And it is important that the haulage should be direct and down hill.

Planting on the alternate double spacing system shown in Plan 2 will greatly facilitate such removals when the forest is at its densest condition, and the removal of these intermediate lines will leave the trees in the plantation equi-distant in squares as shown in Plan 3. Later, intermediate systematic cuttings will leave the trees spaced next as shown in Plan 4, and then as in Plan 5.

For instance, if the spacing in the first instance was 8 feet between the trees in the rows and 4 feet between the rows the number planted per acre would be 1,360. The removal of the intermediate lines in one or two thinnings would leave the trees spaced—square—8 ft. x 8 ft. = 680 per acre as on Plan 3, The first intermediate cutting would leave the trees spaced — triangular spacing — as shown on Plan 4, 16 ft. x 8 ft. = 340 per acre, and the next cutting would leave the trees spaced square, as shown in Plan 5, 16 ft. x 16 ft. = 170 per acre, one-fourth of the original number planted, again to be reduced to half, viz., 85, one-eighth of the original number. Of course this is under a system of systematic and not selection thinning, except so far as that certain species will in order be completely removed.

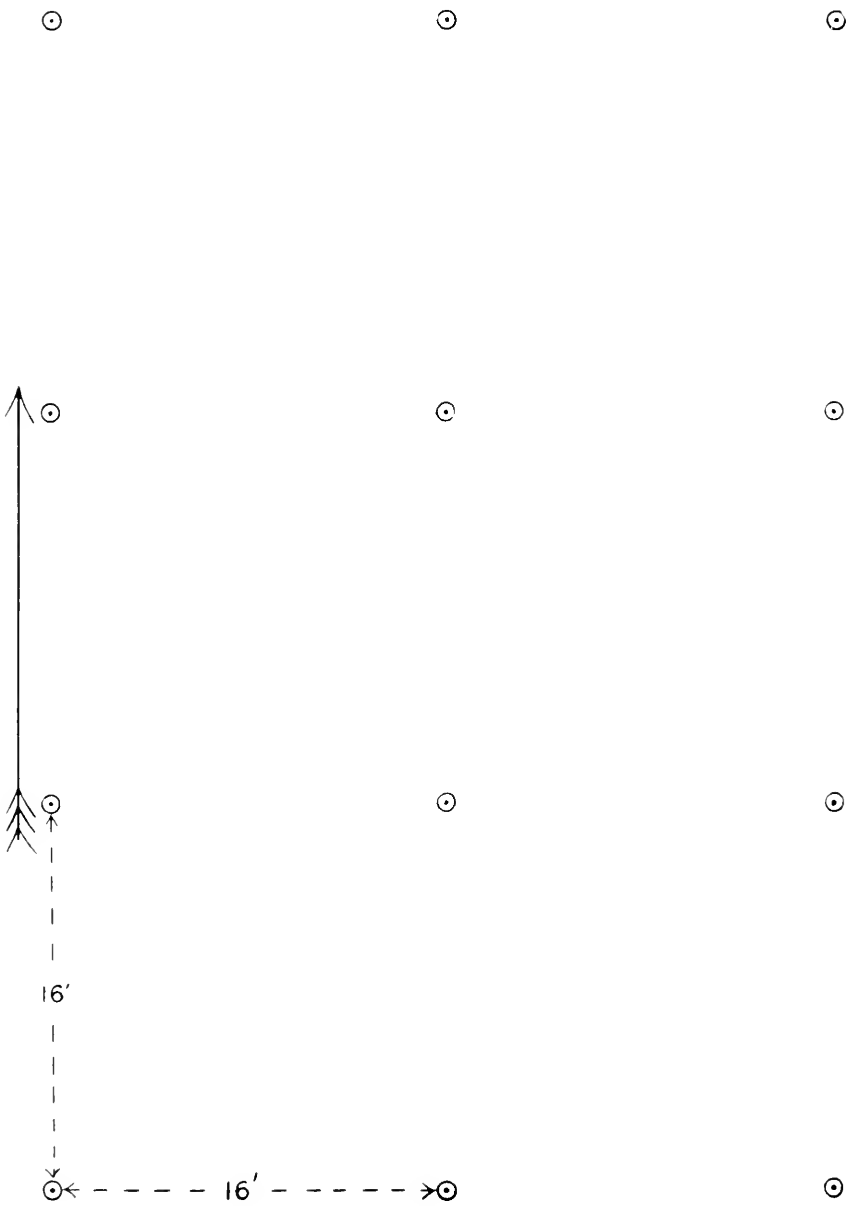
In practice doubtless some few trees would be removed out of order, as their retention in the forest would be of no service and possibly an injury.

Considering such removals out of order and other deficiencies the numbers per acre at the different periods may be taken under such a scheme of planting and spacing as 1,200, 600, 300, 150, and 75. The latter number would be fully high enough to leave for the final crop.

Table I. shows the numbers of trees per acre, both under "Square" and "Alternate Double Spacing." Those on the diagonal line in heavy type are the numbers per acre if planted on the "Square," and the final figures on the cross lines in heavy type are the numbers per acre if the planting is triangular.

Generally the use of guiding poles or sticks and not lines is the best. If poles or sticks are used they should be quite straight and should be marked with different coloured rag—

PLAN 5



say white and red—so that they can be used in pairs, or more, of one colour, each alternate line to be marked being in a different colour so as to prevent accidental cross-sighting.

The marking of every second line to be planted is ample. For example, if the planting team consists of six planters, three can work in line on the marked lines, and three in line behind, the width of a row to one side or other, according to whether the team is working from the right to the left or left to right, planting the unmarked rows, judging the position to plant by the trees planted and by the men in front as in Fig. 9.

Or the planters can work forward in a diagonal line, which is much the better plan. As, for instance, if working from left to right each planter working one plant behind to the right as in Fig. 10. Nos. 1, 3, and 5, being flagged lines, the planters on these keeping correct lines, and those planters on Nos. 1 and 6, being relied upon for keeping correct distances between the plants in the lines, No. 6 seeing that Nos. 2, 3, 4, and 5 keep a true diagonal line between him and No. 1. Of the two the latter system, if followed, is likely to result in more regular spacing throughout, and less delay in effecting it, as all the men are working in one line, and a diagonal line is more directly under the observation of No. 6 than a cross line.

Some advocate the use of a long wire line with links at intervals according to the "spacing" distance adopted. It is contended that accuracy in spacing and straight lines in every direction can so be ensured, but such is only true as applied to perfectly level land. Where the land is uneven and varying in inclination the use of such a line would result in endless trouble and great irregularity in cross and diagonal lines. Using sighting poles for the direct lines, and all planters being kept in line by the experienced man on the right flank will result in much more regular spacing and lines.

Team Work.—Planting should always, when possible, be carried out by team work, and a team of six or over having at least one reliable experienced man in charge, is better than a smaller team.

Team work in practically all forestry operation is most advisable. The spacing, considering the species in "pure stand" or the different species in "mixed stand," the situation and the purpose for which the trees are to be grown, having been decided upon, and the land and plants being ready, a commencement should be made with the line marking.

H

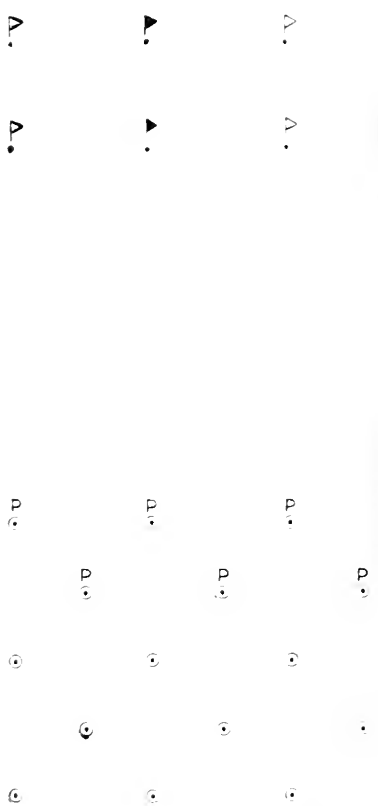


Fig 9

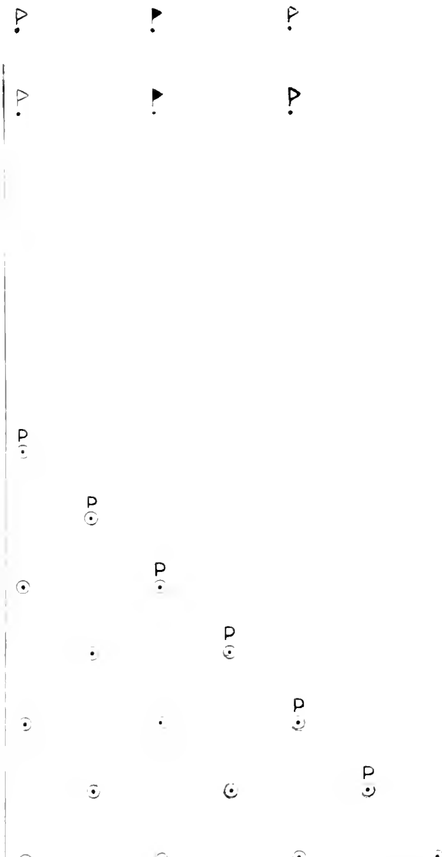


Fig. 10

Spacing.—Assuming regular systematic spacing, which should always be practised where possible, there are several systems of spacing or distribution of plants which are commonly followed.

(1) **Square.**—Where the plants are placed at each of the corners of squares, so that the distance between the plants in the rows is the same as the distance between the rows, and the plants are opposite each other as shown on Plan 3.

This is far the most common system practised, but it has the very marked disadvantage that when the lay-out is such that the direction of the lines is to and from the roads and hauling tracks, or directly up and down hills or inclines, to facilitate felling and hauling, and such a lay-out is most important, and when it is intended to thin and cut intermediate crops by the removal of alternate lines, the removal of the alternate rows in the first instance under this system will leave the trees spaced half the distance in the rows as that of the distance between the rows. For instance, trees that had at first been spaced 6 x 6 would after removal of alternate rows, be spaced 6 x 12, as in Plan 6, Figs. 11 and 12.

(2) **Equilateral triangle.**—This is also a very common system of spacing, but has the same marked disadvantage as (1) "Square" spacing for the same reason. The trees and the rows being nearly equidistant, the removal of the alternate rows would leave the trees apart almost double the distance in the one direction to that in the other as indicated in Plan 7, Figs. 13 and 14.

(3) **Oblong.**—This system is not much practised, and has practically nothing in its favour. Under it the trees are placed opposite each other, either in the one direction approximately twice the distance apart in the rows as the rows are apart, or in the cross direction, half the distance apart as the rows are. The effect is that, instead of being equidistant at the start, as in the case of (1) Square and (2) Equilateral Triangle, and double the distance one direction to that in the other direction when the alternate rows are removed, the position is just reversed, as shown in Plan 7, Figs. 15 and 16.

(4) **Alternate Double Spacing.**—This system has very seldom been followed, in fact may be considered as new, though now being followed to some extent under the advice and direction of the writer. It is a system of placing the trees at double the distance in the rows to that of the distance between the rows, the trees in every second row being placed alternately

PLAN 6

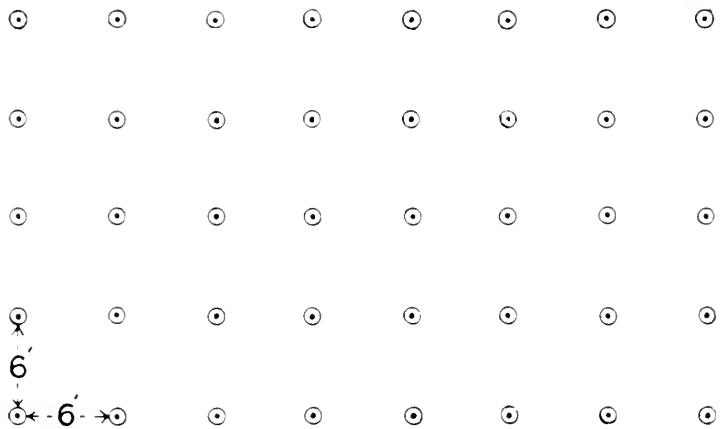


Fig. 11

UNDESIRABLE

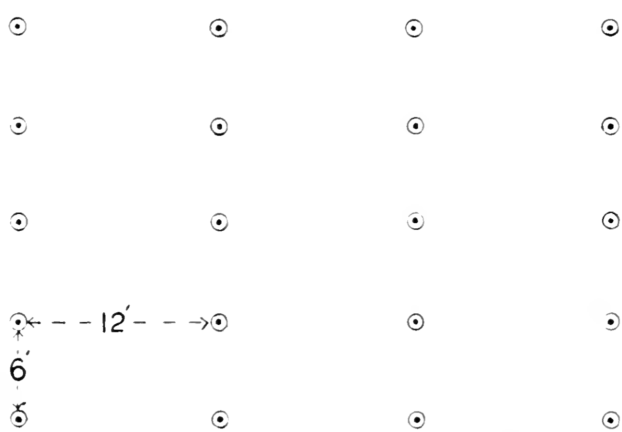


Fig 12

PLAN 7

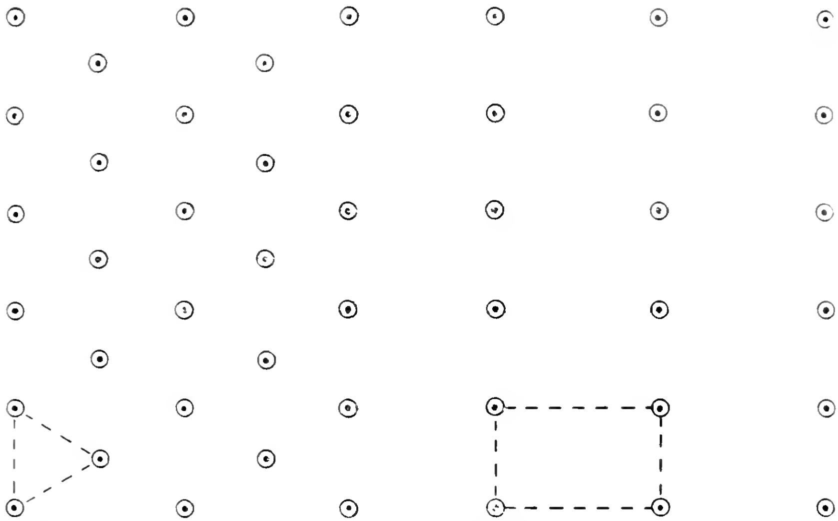


Fig. 13

UNDESIRABLE SYSTEM

Fig. 14

PLAN 7

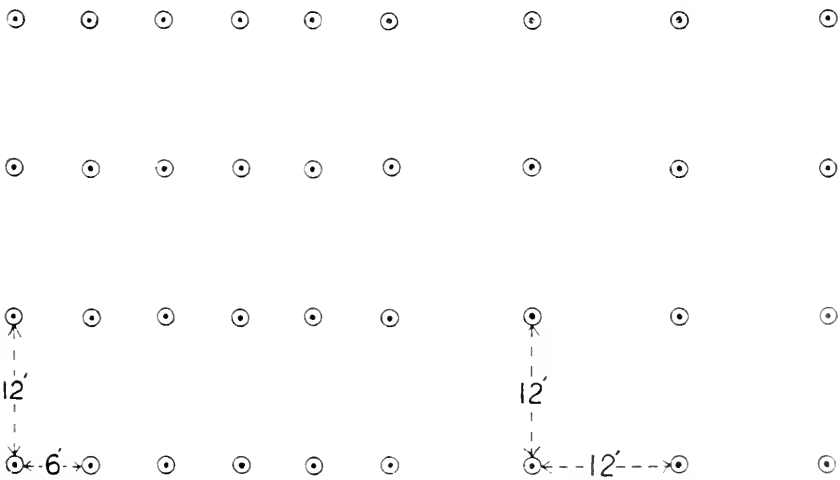


Fig. 15

UNDESIRABLE SYSTEM

Fig. 16

to those on either side, that is to say exactly opposite the middle of the space between the trees in the rows on either side as shown in Plan 2. After the removal of every alternate row by thinning the trees would be spaced as shown in Plan 3.

This system of spacing is in the opinion of the writer far better than any of the other systems, and will doubtless come into general use wherever systematic planting is practised.

In growing Eucalypts, for instance, it is an ideal system, for it facilitates systematic planting at considerable density to ensure height, growth of straight branchless poles with retarded diameter growth so that strength may be obtained, and the cutting and removal of alternate rows with greatest facility and without any injury to the remaining trees in the stand, which are left equally spaced.

Chapter XXV.

PLANTS FOR THE FOREST.

There are two means of establishing a plantation, viz.:—

1. By direct sowing—raising the trees *in situ*.
2. Transplanting—raising the plants in the nursery and transplanting from there to the plantation.

Direct sowing, and so growing the trees *in situ* is the ideal system, and should always be practised wherever the conditions are favourable to success.

It is ideal because only by this method of raising trees can the formation of a perfect root system, upon which so much depends, be ensured.

The conspicuous advantages resulting from the establishment of a perfect root system are rapid symmetrical growth of the young plants, much more rapid growth of the young trees, more sure, healthy, unretarded growth later in life, longer life, and at all times greater wind firmness.

It is certainly especially ideal for many species of trees, most advisable for purposes of afforestation in our southern lands.

Wattles, Eucalypts, and some Pines—particularly the Canary Island pine, because of its exceedingly bad trans-

planting quality—and also for the same reason the Sugar gum (*E. corynocalyx*), Yate (*E. cornuta*), and others.

On the other hand species which are excellent transplanters but slow growers when young, can best be dealt with by being raised and cared for in the nursery for some years. Among such are Redwood (*Sequoia sempervirens*), Oregon (*Pseudotsuga taxifolia*), Western Red Cedar (*Thuya plicata*), and Bald or Swamp Cypress (*Taxodium distichum*), and for a shorter time Macrocarpa (*Cupressus macrocarpa*).

Direct Sowing.—The conditions most favourable for direct sowing are—

1. Where weeds or other growth will not be too rank to permit of seedlings getting ahead of such growth.
2. Where the configuration and condition of the land is such as will permit of the use of implements—plough, harrow, drill, or spot-sower. Hand sowing may be resorted to on occasions, for instance in small portions that cannot be dealt with by other means.

Ploughing and cultivation are most desirable wherever circumstances permit. If the surface of the soil is sufficiently free and clear it may be that success can be attained without ploughing, possibly by just scarifying, or even in some loose soils without even that.

Practically always it will be advantageous to use, when drilling in or otherwise sowing seed, such fertilizers as are found suitable for the species being sown in the soil of the situation.

When once established young trees and older trees of many species are not sensitive to much extent to the degree of fertility of the soil, but seedlings and quite young trees are distinctly so, and fertilizers can generally be used with considerable advantage.

The disadvantages of and bars to direct "*in situ*" sowing consist of heavy weed growth, the depredations of animals and insects, and in some cases over exposure to heat, drying winds, etc.

If the weed growth is such as to cover the seedlings before they have grown sufficiently to be easily seen and effectively cleaned direct sowing is impracticable. Also if rabbits, hares, or other pests are bad so many seedlings may be destroyed that the plantation will become faulty or then too costly to maintain, and any advantage in having a certain number of trees in the

plantation established with a perfect root system may be altogether discounted by the faultiness of the "stand."

Further, direct sowing cannot be adopted for the establishment of a systematic "mixed" plantation.

Transplants.—When it is impracticable to establish a plantation by direct sowing the next best thing is to use the youngest plants, not the smallest, but young, well grown, sturdy plants. If such plants have any loose or over-long rootlets they should be cut off with a sharp knife. None of the roots will have grown to any such extent that would prevent them, with reasonable care, being planted without entangling, crossing, or twisting of the roots, or that would prevent a fairly good root system being formed. Any root pruning should be done at the time of lifting and grading in the nursery.

Older plants and any that have been transplanted more than once in the nursery, having formed considerable roots, cannot be relied upon to form a proper root system, unless an amount of care is taken that it is often impracticable to take when planting out in great numbers in a plantation.

Wattles, Eucalypts, Pinus insignis, P. pinaster, and many others can best be established, if conditions prevent direct sowing, by planting out as young seedlings. It is distinctly inadvisable to use large plants of any of these species for general planting unless the conditions are distinctly unfavourable—such as in rough places, amongst logs and stumps where other growth is heavy—for the use of small plants.

It is desirable to use specially selected sturdy and fairly large plants for replacement work, and extra care should be taken in the handling and planting of these so that every opportunity be given them to catch up in growth to the plants surrounding them.

Although all species will make better growth in every way and be far more wind-firm if grown direct from seed and not transplanted at any time, if the conditions are favourable and, although failing the practicability of adopting this course, the next best course is, as already stated, to use small sturdy plants, conditions will never be sufficiently favourable, except at excessive cost, to adopt either of these courses with some important species such as those already mentioned.

Redwood, Oregon, Western Red Cedar, Lawsoniana, Bald Cypress, and, to a lesser degree, Macrocarpa. These must be raised in the nursery and transplanted several times before

they are fit to put out in the plantation, as the cost of tending them in the plantation for two or more years would be prohibitive.

Besides being, with the exception of the Macrocarpa, excellent transplanters, the fact that any of these species would seldom form more than a very small proportion of the total number in any plantation, being the species of which the final crop would consist, density being obtained with other species, would permit of very special care in handling and planting the lesser number of large plants.

Preparation and Handling of Plants.—There are, of course, different methods of dealing with seedlings and young plants. These methods vary according to (1) the species being dealt with, (2) the distance and means by which they have to be conveyed between the nursery and the plantation, (3) the nature and condition of the soil of the plantation site, and (4) the climate and season.

In some cases the sensitiveness of the species dealt with, the distance the plants have to be conveyed, the nature and condition of the soil, heat, or lack of moisture, may make it advisable to have the seedlings in trays and even to have them so that they may be lifted individually with soil surrounding the roots, but usually—in fact in probably ninety-nine cases out of a hundred—if the seedlings have been properly raised and dealt with, that is if they have been raised in narrow seed rows, not densely, and sufficiently exposed so as not to be tender, in soil of quality and condition that has promoted good roots—plenty of small fibrous roots—and the growth of sturdy short thick-stemmed plants which have been properly and thoroughly wrenched, lifted when there is a good show of new white rootlets, graded properly, kept from the sun or drying air, and moist, placed together in bundles, moist and fairly tight, with roots—if advisable—covered with moss, or then puddled in mud or just wetted, the plants can be conveyed to the plantation and planted—if planted with care as directed—with assurance of practically a hundred per cent. success.

If the weather is at all dry it is advisable, just at time of taking out to plant, to puddle the roots of the young plants—taking bundles of ten or twelve or twenty or thirty according to size—in mud mixed sufficiently wet just to adhere to the roots. The plants should, when being carried along the rows and during planting, be carried by the planters in a tin or some convenient conveyer, or rolled in a sack where the roots

remain in contact with moisture, and from which each plant can at the moment for planting be easily withdrawn.

There are, of course, cases where special methods have to be adopted, as for instance with the Canary Island pine, which is perhaps the most sensitive of all species. In such cases raising *in situ* is probably the only satisfactory method.

Chapter XXVI.

SELECTION OF SPECIES.

The "location" of an intended forest having been settled the forester's first business is to study the "situation" so as to judge as far as possible the extreme range of species that will thrive well in it, and taking into consideration that range of species and the location of the forest and facilities of transport, ascertain what prospective markets can best be supplied.

His next business is to select from the full range of species those which will thrive best, and at the same time best suit the market.

A species which produces timber reasonably suitable for a certain purpose and which can be relied upon as a rapid grower in the particular situation should be selected in preference to a species which produces a finer or even much finer timber for the purpose but which is a less reliable and a much slower grower. Not only should the average growth over the whole period, up to marketable size, be considered in the comparison, but also the facility or otherwise with which it can be established. That is the percentage of successful takes and its ability to rapidly outgrow weed and other growth. As has been elsewhere pointed out, replacing, weeding, and cleaning are very costly operations, and therefore in the case of species which require an excess of these operations such must be taken fully into account. The degree of fire risk must also be considered.

Where a species that would produce a higher class timber for the purpose required, is passed over in favour of a species that will produce a timber that will reasonably answer the purpose, the chief quality that is desired should, of course, be given the fullest consideration. If that quality is durability,

then it should be known that a sufficient durability can be obtained by the use of preservatives. If it is strength, that sufficient strength can be obtained without adding too great bulk.

In the case of poles, strength and durability without great bulk is necessary, therefore the choice, in what may be termed inferior species, is limited in range to those which are either naturally of the required strength, or can be so grown as to have the required strength without undue increase in bulk. Such may lack enough natural durability, but by the use of preservatives a sufficient degree may be obtained.

In southern lands the great bearing that forestry methods have on the qualities of timbers, particularly as affecting strength, has unfortunately been much overlooked. Especially is that the case in New Zealand, where it might be said it has been almost entirely ignored.

For instance, the timber of the Pinus insignis has in Australia and New Zealand obtained a reputation as a weak, coarse-grained, knotty timber. This reputation is quite undeserved, and is wholly due to the entire neglect to practise proper sylvicultural methods.

Illustrations 1 and 2, pages 25 and 32, indicate very clearly how greatly the quality of the timber of a species is affected by the way it is grown.

Again, whilst the timber of the Redwood (*Sequoia sempervirens*) is one of the most valuable in the world, the New Zealand State Forest Service has practically condemned the New Zealand grown Redwood by ignoring proper sylvicultural methods and then comparing the timber of young trees grown under conditions that permitted an annual diameter growth of one inch, with Californian grown timber that took ten years to the inch.

The timber ot Eucalypts grown in New Zealand has been condemned because the quality of that which has been grown as almost independent trees or then in very over open plantation, where diameter growth of from half to one inch per annum has been made instead of that of dense planting where the diameter growth would be so retarded as to prevent half that diameter growth being made.

Before selecting the various species to be grown the forester should, besides having thorough knowledge of all their qualities both as to growth and the timber, ascertain as fully as possible all local information. Pending more complete informa-

tion, any early permanent planting should be limited to such species about which there is little doubt. Fuller local knowledge should be immediately sought by the establishment of an experimental area.

Beyond a few species which may be indifferent to variation of climatic and soil conditions, no amount of general knowledge and information, or even of information as applied to parts of a district, is sufficient to warrant extensive planting of many apparently suitable species without definite knowledge as applies to the actual situation.

Experimental Area.—The first actual planting operation should be the planting of an Experimental Area, which should be established in a situation which is a fair average of the particular area which is to be afforested, and should be established under the same conditions, possibly more than one set, as to preparation of the site, kind of plants, style of planting, and degree of care in maintenance, that will be followed in the general planting operations.

The range of species dealt with should include those of which there is no doubt as to their suitability, and extend to all of which there is any reasonable likelihood of success.

There is no need for any great number of each species—some two to three hundred of each species would be ample. The spacing should be "dense" and the different species should be planted in order of their supposed rate of growth, from the most assured rapid growers down to those from which the least success is anticipated.

The plots should be from four to eight rows wide, and should be separated from each other only by the same distance as that between the rows.

If a test is desired to be made between two sets of conditions such as that of ploughed and unploughed land the plots might best be narrow and long—say four trees wide and fifty deep—but if only one set of conditions were being tried eight trees wide and twenty-five deep.

To indicate how important actual local knowledge is, the following is enlightening:—An "Experimental Area" was established on the property of the Taranaki Forestry Company, near New Plymouth, in a central position of the proposed forest. One part of it consisted of twenty species of Eucalypts and the plots of the different species were arranged in order of sequence of anticipated rates of growth, based upon ascertained rates of growth in many parts, including that of some

of the species in situations within comparatively a few miles of the locality of the experiment. The actual, compared with anticipated, growth shown in feet of height growth for $2\frac{1}{2}$ years was as below:—

Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Anticipated	20	20	20	19	18	17	17	14	14	14	14	14	9	9	8	6	6	4	4	4
Actual	19	26	13	23	24	11	16	17	24	25	4	17	8	8	8	8	16	13	9	2

Although knowledge of rates of growth during such a short period as $2\frac{1}{2}$ years is not sufficient guide by itself, it is fairly so in conjunction with general knowledge of comparative rates over longer periods elsewhere.

Whilst knowledge of the rate of growth likely to be made by each species in the actual situation of a plantation is of great importance in the case of "pure" planting, it is of absolutely vital importance in the case of "mixed" planting to know as exactly as possible the comparative rates of growth of all the species within the range of choice that the situation and prospective market will permit, for, in deciding upon the particular species in the composition of a mixture, any considerable discrepancy between the rate of growth indicated by general knowledge and the actual, but unknown, local growth would entirely upset the forester's calculations, and be fatal to the success of the "mixed" plantation.

Take for instance the results displayed by the experiment in Eucalypts, and presume the experiment to have been, instead of one of all Eucalypts, one of Pines, Eucalypts and others and the composition of a mixture to have been based on the anticipation under Nos. 2 and 3, resulting in a growth of 26 feet and 13 feet, instead of both growing 20 feet, or even on that of Nos. 12 and 13. In each case one species making practically double the growth of the other instead of equal growth. Such results, or even less than half such a discrepancy, would be absolutely disastrous to the "mixture," as the slower growing species would be quickly suppressed, and the plantation would be very much understocked, and consequently over open, followed by increased fire risk, much lower grade timber, and probably less yield.

Chapter XXVII.

REPRODUCTION.

The term reproduction is intended to embrace continual re-growth within the standing forest and also re-establishment, whether by natural or artificial means after final clear cutting as a whole or by a series of strips or blocks.

As the object of this work is primarily to deal with afforestation, what is or is not the best treatment to improve and ensure a satisfactory continuance of natural grown forests does not come into consideration.

In any scheme for reproduction the overruling considerations must be the same as in the case of establishment in the first case, viz., high yield of high grade timber, in the shortest time, at the lowest cost, near the market. Assuming the locality and the situation to be favourable a fully stocked stand at all periods of growth is an absolute essential towards these ends.

A fully stocked stand can only be established and maintained by regular systematic planting, regular even unbroken growth and complete canopy, and by density proportionate to root and branch requirements being maintained throughout—that is that thinnings and intermediate cuttings be not made in excess of what is necessary for steady healthy growth.

In open stands and in forests of the Northern Hemisphere, in which many broad-leafed deciduous trees and species of conifers and others, other than those suitable for our southern lands, continuous re-growth within the forest is practicable, but it does not follow that it is so in our southern lands, and it may be accepted that, if the system of full stocked stand is adhered to, it is quite impracticable, and therefore is left out of consideration here.

There are two courses, each suited to different conditions, open for purposes of renewal of crops, viz., (1) by under-planting, and (2) by re-establishment after felling.

Under-planting.—Here under-planting is only being considered as applied to dealing with a stand which has reached or nearly reached its full height growth, and not with planting after some species that on account of slower growth required a start.

Under some conditions there may be a benefit to be derived by under-planting in the case of some sparse-foliaged species

of pines, but the special circumstances as to the growth of the trees, the condition of the forest floor, etc., must necessarily be the deciding factors.

On the other hand in the case of Eucalypts, many species, though planted fully densely in the first instance, and only thinned to the extent required to allow of satisfactory growth, become as they attain height so little shade giving that the forest floor becomes unduly exposed. Under such circumstances, as when it is desired to maintain the stand of Eucalypts for a considerable number of years to attain greater size, and especially, further maturity, under-planting is most desirable and further is necessary to prevent injury to the soil.

This also offers the most favourable opportunity to grow some species that produce high grade timber but which require a long rotation.

The small degree of shade-giving quality of some species of Eucalypts makes under-planting less of a problem for the reason that choice of species for under-planting is not restricted to the distinctly shade-bearing ones, and can be extended to some that have that quality to a much lesser extent.

Of course, if success is to be attained in either case, the choice is restricted by the qualities of the situation.

But it must be borne in mind that whatever other qualities the situation may afford in the case of growing a dense stand of Eucalyptus, and particularly so in the case of under-planting an open stand of Eucalyptus with other kinds such as conifers, ample moisture is essential to continued success.

Amongst the species of trees suitable for afforestation in our southern lands the following are some that are suitable for under-planting Eucalypts:—

Pinus insignis	Sequoia sempervirens (Redwood)
,, pinaster (Cluster pine)	Pseudotsuga taxifolia (Oregon)
,, canariensis (Canary Island pine)	Cup. Lawsoniana
Cup. macrocarpa	Thuja plicata (Western Red cedar)

Of these Insignis and Pinaster perhaps are the most reliable in the greater variety of situations, but of the two Pinaster, though less shade-bearing, is the more suitable in hotter and drier climatic conditions, and where the soil is over poor or over sandy.

Next to these come the Macrocarpa and Lawsoniana, but all the rest require especially favourable situations.

Redwood, Macrocarpa, Lawsoniana, Oregon, Western Red Cedar, and the Canary Island Pine thrive well if the situation is otherwise suitable, in association with New Zealand native forest trees.

Re-establishment after felling.—This may be brought about, under certain circumstances, by any of the following means, separately or combined:—

(1) Natural regeneration from seed.
(2) Natural re-growth from sprouts, and
(3) Re-planting.

Natural regeneration from seed.—Under this, success as to actual reproduction, apart from the advisability or otherwise, depends upon certain conditions as follows:—Either the species must be such as will leave ample fertile seed on the ground when the crop is felled, or then when the felling is being carried out sufficient seed-bearing trees of the one species or the different species in the case of a "mixed" stand, must be left standing, or failing either of these the felling must be restricted to narrow strips or small blocks, so that sufficient seed from the trees on the margins will be distributed over the whole of the area felled.

Bearing in mind the almost imperative importance of a fully stocked systematic even stand, the great disadvantages of this method are so obvious as to hardly need mention. Out of the general hopeless disorder and the extremely varying density resulting from re-growth so brought about, it would be practically impossible to produce anything like regularity, and all thinning operations would be troublesome and costly, and intermediate crops would not only be difficult to fell but also impossible without some injury to the trees remaining. Also, all logging operations would be more difficult and costly.

This means of regeneration has the further disadvantage that it enforces a repetition of the same crop or crops as the former, and in the case of a "mixed" plantation, the species least wanted may be reproduced in undue excess. Further, change cannot be made to suit soil conditions or a different market demand.

On the other hand, notwithstanding all such disadvantages, there will exist special conditions which will make natural regeneration from seed or from sprout or from both combined advisable. For instance, in the case of excessively rough or over steep places or places much encumbered with rocks or

other obstructions making systematic planting impossible or excessively costly.

Natural re-growth by sprouts.—This means has the very distinct advantage over natural regeneration by seed, in that in spacing it would be systematically regular, though possibly irregular in growth. It also is good in so far as it much more rapidly re-covers the forest floor, but it has the same disadvantage of being a repetition of the crop. However, so far as our southern lands are concerned it is very narrowly limited in practice as very few species worth growing sprout from the roots.

It is of great importance as applied to Eucalypts, but it has to be remembered that the extremely rapid growth of sprout wood renders it inferior, bulk for bulk to that of the original crop timber grown under proper conditions.

If re-growth of Eucalypts is desired the trees should be cut between April and October, and so cut as to leave low or very low stumps.

Whilst most of the Wattles sprout and sucker badly, the most valuable one for production of tanning bark, and excellent for fuel, and fairly good for fencing—Acacia decurrens, var. mollis, the Black Wattle—does not sprout.

Among other trees valuable for afforestation in our southern lands, the Redwood and the Canary Island Pine sprout. The Redwood sprouts freely, and the sprouts make rapid growth.

Re-planting.—The advantages of re-planting over any other means towards reproduction are:—

(1) That it can be carried out with regular systematic spacing, which gives every tree equal room, makes possible complete stocking, and facilitates all operations in the forest, and the removal of all material.

(2) It permits a change of crop to suit soil requirements or change of market.

(3) It permits of change from "mixed" to "pure," or from "pure" to "mixed," and obviously also permits free decision as to the composition of a "mixture" and the exact proportions and relative position of each species in the composition.

The disadvantages are:—

(1) Possibly greater initial cost of re-establishment, though later costs would be much less.

(2) In some instances fuller exposure of the forest floor. Usually there would be a natural re-growth that

would take place concurrently, which would as quickly protect the forest floor as if reproduction was to be secured by seeding or by sprouts. This re-growth would have, later, in some instances, to be slashed back.

In any case, whether the means towards reproduction is by natural regeneration from seed or from re-growth by sprouts or by re-planting, the smaller the compartments exposed and to be dealt with at one time the less would be the injury to the soil, and the greater the protection afforded to the young crop. The systems of felling towards this end are indicated elsewhere.

Short rotation crops.—Of course if the crop is to be raised for the purpose of production of small material, such as firewood or small poles, or for some wood products, and if, therefore, it is intended to clear cut on a short rotation and no more than, at the most, one thining would be made, and that early, the disorder of a naturally regenerated crop would be of little consequence.

Chapter XXVIII.

SHELTER AND FARM WOODLOTS.

The term **Woodlot** has been adopted for the farm class of plantation.

There may be circumstances, but it is difficult to imagine them, when no advantage is to be gained by sheltering the margins of a plantation.

Exposure to, and the entrance of, cold and drying winds is in every way injurious to the forest. Violent changes of temperature and degree of humidity not only directly affect the health and growth of the trees, but also create conditions unfavourable to steady progress of conversion of waste material into humus, so necessary to the proper building up of the forest floor. Such changes, and the arresting, caused by drying winds, from time to time of steady decomposition of humus not only interferes with the health and growth of the trees, and so lessens the annual increment, but the quality of the timber is injuriously affected. Also resistance to disease is lessened.

In contrast to violent changes of temperature and degree of humidity, it is of great importance that both should be, within the forest, as equable as possible, and so that such conditions may be maintained cold and drying winds must be kept out. Also it is of vital importance that the plantations should be maintained in as fire-proof a condition as possible. Such can not be if the margins are open so that fire by sparks or flames can be driven in, or if the wind can enter to fan and spread any internal fires that may occur.

If a plantation is composed of a species of tree the lower branches of which naturally continue in full growth if not shaded by other trees, or that can, by a degree of trimming, as earlier described, be made to retain them in a green and growing condition, a sufficiently wind-tight margin can be made of the outer row of the plantation, but if in a "pure" plantation the species of which it consists is not of such a nature, or if, in a mixed plantation, none of the species are, then either a special suitable outer edge or margin or a suitable fire-resisting hedge should be planted.

The question of what are suitable species of trees or kinds of hedge plants is a difficult one, and the forester must be guided by the composition of the plantation, the conditions of the situation, and by his local knowledge.

The height to which the trees, of which the plantation consists, will grow in the situation has a great bearing on the choice, especially as affecting the sunless side or sides. It may be that a special margin of some width of a species that grows only to a medium height will have to be planted, and then possibly, in addition, another species for the actual outer edge.

When considering the question of shelter-giving margins and any trouble and expense connected therewith, it has to be borne in mind that usually the lack of proper shelter on the margins will very detrimentally affect the quality of the timber to be obtained, especially that from the trees growing near the margins.

The species of trees of which a plantation consists may be hardy and may appear to be little affected by lack of shelter but nevertheless their ultimate growth may, as a consequence, be very considerably less than it might have been had the plantation been properly sheltered, and also the liability to disease will likely be much increased.

As elsewhere mentioned the Insignis pine can be so treated, by trimming the outer face, as to make an excellent wall.

Certain hedge plants can be grown in conjuction with it. Boxthorn, where soil is good, well drained, and free from sourness, will on the sunny side grow to a great height, fastening itself in among the branches.

Eleagnus japonica, which is much less particular about quality and conditions of soil, and unlike the Boxthorn, will thrive well where there is no direct sunlight, and therefore is suitable for hedge purposes on the shady sides, will grow fifty feet or more up against and into the supporting pines, making a perfect, dense wall.

Pinus pinaster, though a poor shelter tree by itself because of the sparseness of its branches and foliage, makes, for these very reasons, an excellent support for hedges of various kinds, including Boxthorn and Eleagnus. Cupressus macrocarpa, especially when the outer face has been trimmed from the first, C. Lawsoniana, and many other species such as Pinus muricata, are suitable for the purpose of giving dense shelter without the addition of hedges.

The drawback to many is that they are slow growing, and so may fall unduly behind, in rate of growth, that of the species of which the plantation may consist; for this reason the Insignis pine has great advantages over many others because of its very rapid growth though that advantage is saddled with the need of proper trimming.

The presence of marginal shelter is especially beneficial at times of thinning, and the cutting of intermediate crops, and also at the time of clear cutting it may be retained and so be of immense benefit in lessening deterioration of the soil during exposure and in protecting re-growth when natural regeneration is being relied on, or of the young plants in the case of re-planting.

Shelter on the Farm and Farm Woodlots.—Adequate shelter on the farm, for the homestead, the stock, crops, and pasture, is all important.

Comfort for the home, shelter for the stock, both from cold and heat, shelter for crops, pasture and soil from the ill effects of cold and drying winds are all conducive to successful farming, and to making country life attractive.

Stock of all kinds, but especially dairy cattle, will thrive and resist disease much better when there is adequate shelter for them during severe weather conditions.

Cattle will keep in better condition and suffer less ill effects if fully sheltered from cold winds, even if short of food for the time being, than they will, with ample food if exposed.

Whilst the proportion of farm areas that can profitably be devoted to the purposes of shelter will necessarily vary with the situation, climatic conditions and the class of stock carried, in some cases 80% of the area would carry as much stock and keep them in more thriving condition with the other 20% occupied by shelter judiciously situated than the whole area in pasture and crops would if lacking shelter.

It is hardly possible to over-estimate the value of shelter, in some climates, in the case of a dairy herd for instance.

Further, wherever reasonably practicable all the needs of the farm in firewood, fencing, poles, etc., should be grown on the farm, in the farm "woodlot" or "woodlots," whether such is independent of or part of the shelter provided. According to circumstances the woodlot may provide small and large material for sale beyond the needs of the farm.

The outer faces of shelter belts, blocks of shelter and of woodlots, or any side exposed to trying winds can be treated much in the same way as the margins of plantations.

In cases where it is not desired to have a wide belt, but when the belt would be subject to strong winds, especially where the belt is broadside on to the wind, a single row of trees with, say, a hedge at the back, may not be sufficiently strong to withstand the force of a heavy gale, and the risk is great where there is a hardpan, it is advisable to plant at least two rows of trees so spaced that those in one row are opposite the middle of the intervals between the trees in adjoining rows, the spacings so forming a continuance of triangles. The space between the rows should be rather less than that between the trees in the rows. The distances will, of course, vary according to the species and the number of rows.

Woodlot.—Though the farm woodlot may be designed to provide timber for sale as well as for home use, and even ultimately timber large enough for milling, obviously there is more latitude permissible in the composition of the woodlot than in forest plantations, as much of that required from the former would be round and small-wood, but in the main most of what applies to a forest plantation also applies to the woodlot, and particularly so does all pertaining to protection against fire and the entry of wind.

The writer was recently asked "how small a plantation was worth while?" The answer was, of course, that the need for the material and the position of the woodlots must necessarily be largely the deciding factors, but that a woodlot could hardly be so small as not to be worth while, considering the immense quantity of material, suitable for the needs of a farm, that can be got off an acre or even a quarter of an acre of land. Obviously it would not be advisable to plant species for the production of large timbers on an extremely small area. Wattles and gums, with possibly Macrocarpas, for instance, for shelter on the outside, are excellent for farm woodlots. C. macrocarpa is excellent for growing on the farm both for shelter and for fencing, poles, and firewood. It thrives better planted in open native bush than in any other place, standing a fair amount of shade as long as there is top light.

The farm woodlot or woodlots may be in such position as to act as shelter as well as providing wood, and for that reason may be best in small lots in several different parts of the farm, and may be so placed as to act as protection to water courses or as cover for broken uncultivatable corners which otherwise may be a danger to stock or act as weed beds.

Weed destroyers.—Cover from most trees will more or less kill or weaken weeds, but some species are especially good weed destroyers. Most pines, some gums, and several wattles are good. Of the pines none is better than the Insignis, and of the Wattles, the Black Wattle (*Acacia decurrens* var. *mollis*), is good, but even better is *A. decurrens* var. *normalis* (Sydney green or Sydney golden) and the Blackwood (*Acacia melanoxylon*), but the latter is a very bad one to sucker. To kill out weeds dense cover is essential, therefore close planting and cleaning of margins is necessary.

Animals.—Very frequently plantations, and especially farm woodlots are very seriously damaged or practically destroyed by stock breaking in or being put in. The latter is often done under the impression that they will do little or no harm. Stock should never be allowed into forest plantation, and certainly not into woodlots, until the trees have grown quite large. They are better kept out always, but some farm woodlots when grown may afford such excellent sheltered camping ground for cattle that any disadvantage may be thus fully compensated for.

Chapter XXIX.

WORKING PLANS.

As opposed to the system of continuous selection cutting, and reproduction so that year after year, the year's quota of timber can be taken from the forest, practised in many European and other forests, and which could be applied to some natural forests in our southern lands, afforestation in these lands should aim at a system (one that is applied to some forests elsewhere) that of "clear" cutting the residue, after all thinnings and intermediate crops, the year's quota of a series of compartments or blocks.

Any afforestation operations, whether of State Services or others, that are just schemes for covering many thousands of acres of land with one, or perhaps more, species of trees regardless of the class or the grade of timber that will be produced, regardless of how the necessary sylvicultural operations can be carried out, regardless as to position, as to the market, or as to the probable requirements of the market or the use to which the produce can be put, and regardless of any scheme for regular annual cuttings, or as to facilities for working, fails in essentials of scientific forestry and working of the forests.

Afforestation for timber purposes should be carried out in such locations as the produce from which can obtain easy and cheap access to the market. It should be with such species, so planted and tended, as will produce timber of such classes and in such proportion as will most suit the market or purposes intended.

The lay-out of the planting should be such as to give the greatest facility for cutting and removal at the least cost of all produce—thinnings, intermediate, and final crops—and also so that each year's cutting may be done in proper sequence as to age, in required proportions of each class of timber and in regular progression as to amount.

Further, so that it will provide according to the kinds of timber grown, the market to be supplied, the configuration of the country, etc., for the most desirable system of cutting both as affects cost of working and cutting, facility and method of regeneration, and further the protection of the forest floor and of the new crop—(1) whether clear cutting of the whole area is proposed, or (2) by alternate strips or blocks or com-

partments, or (3) on the other hand by cutting every strip or block of the given area but leaving standing complete boundaries of each, consisting of such as covered fire-breaks, forest margins, and other narrow strips surrounding each strip or block so that the forest floor and the new crop in each compartment will be sheltered.

Such compartment boundaries, which would include forest margins, may consist of species of trees which will produce high quality timber but which are slow growing and require two, three, or more times the length of rotation period required by those of the main crop.

It is the duty of the forester, right at the start, to work out a comprehensive scheme that will provide for every operation from establishment to exploitation and regeneration, being so planned and carried out as best to ensure the whole scheme working out a success economically and financially. In other words that the scheme is not one for planting trees but for the production of high grade timber, quickly at low cost, and at the same time having increased the fertility of the soil and provided for re-establishment.

Chapter XXX.

FIRE RISK AND PREVENTION.

Fires and disease are the two great bugbears of the forester, and as prevention is always better than cure, he should, and if he knows his business will, do all that is possible to first prevent attack, next to prevent incipient or small fires growing to dangerous conflagrations, and lastly to confine the latter, if occurring, to the smallest area.

Causes of Fire.—Undoubtedly far and away the greatest number of forest fires are caused by carelessness, direct or indirect. Many are due to ignorance of the risk, and some few are due to pure accident. If the public realized the great risk of fire and exercised reasonable care very few fires would occur.

The chief causes of fire are—

(1) The carelessly thrown down smokers' matches.

(2) Camp fires carelessly lit or not sufficiently put out by picknickers, campers, sportsmen, trappers, swaggers, and others.
(3) Promiscuous burning of bush, scrub, grass, etc., by neighbours, or even by those at a considerable distance.
(4) Sparks from railway or other engines or furnaces, or even from house fires.
(5) Burning of waste and other material intentionally within or around the forest is, through lack of care, a frequent cause, and has resulted in destruction of many plantations.
(6) Deliberate starting or neglect to prevent spread with malicious intent.
(7) Natural causes, such as lightning.

The causes or origins of fires, the manner and means of extinction, and the conditions which render them a menace are the guides to the forester as to what he has to cope with.

In the scarcity of inflammable material, in moist conditions, and in the absence of, or little, wind, fire can hardly be considered a menace; on the other hand, dry, or even moist, conditions, much inflammable material, and a gale, or even a strong wind, render a fire not only a menace but a likely forerunner of a disastrous conflagration. The forester's efforts should, therefore, be directed towards preventing outbreaks, preventing the extension of such as occur, and providing against, or modifying as much as possible, the complete combination of the most dangerous conditions.

True, the occurrence of wind cannot be prevented, but it can be more or less excluded from, or greatly modified within, the forest. Dry periods cannot be prevented, but the forest can be so established and protected as to maintain within it generally more humid condition.

But the greatest cause of damage, and of serious conflagrations, the presence around and within the forest, of quantities of inflammable material, can be very greatly reduced, if not entirely removed, by the forester by initial and continued proper practices.

Kinds of Fires.—Forest fires are of three kinds—

1. Ground fires, being those which burn under the loose surface in the humus.
2. Surface fires, being those which burn the grass or other low growth or loose material on the surface.

3. Crown fires, being those which get into and burn among the branches and tops of the trees.

Ground fires do little more than smoulder and progress very slowly, but are hard to deal with, and may continue for a very extended time, and under certain conditions are practically only extinguishable by heavy rains or a handy ample supply of water.

Surface fires should be easily coped with, especially if early detected, provided the forest has been established on right lines, properly maintained, and protected.

Crown fires, on the other hand, if once fairly started during a strong wind in any part where exposed to the wind, are exceedingly hard to cope with. Actual direct attack on such fires is generally practically impossible. The use of explosives may in some cases be effective, but usually the only reasonably sure way is stopping wide extension by back-burning from the nearest fire-lines, roads, or tracks to the leeward.

These very difficulties, and the menace of extensive damage, makes imperative on the forester that all possible precautions to prevent the danger of a surface fire developing into a crown fire, or a crown fire occurring direct from external sources.

Protection from fire.—The first and chief protection is the making each unit of the forest in itself as tight a fire-proof compartment as is possible. In the attainment of this enters the several matters, viz., species, composition of mixtures, density of planting, keeping a fully stocked stand, early decay of dead material, proper condition of the forest floor, keeping of the outer edges as far as possible closed against entrance of fire and wind by a green face, preferably consisting of fire-resisting species, and clear of all inflammable material.

The next in order of protection is the keeping of all the forest margins, roads, intersecting lines, etc., clear of all inflammable material.

Next to making each compartment of the forest as far as possible fire resisting comes the questions of preventing the starting of fires, the detection of those started, and organisation to cope with outbreaks.

Far the greatest protection against fires occurring in the forest is dense planting—a fully stocked stand without break in the dense canopy. By dense planting and even, unbroken growth, a complete cover is early obtained to the forest floor, resulting in all weed and other undergrowth and all lower branches being quickly killed off and destroyed, so that in a

few years there is no body of inflammable material to carry flames through the forest or up into the crowns. The decaying material on the forest floor if set on fire will usually do little more than smoulder if the density of the forest and the closeness of its margins are such as to practically exclude any wind that would drive the fire. Such a fire should be detected and checked before any serious damage is done. The density of the canopy, which is all green on the upper surface, prevents any wind-driven sparks reaching anything that will burn. The complete canopy also keeps the forest floor in a far damper and therefore much less inflammable condition for a much longer time, into dry periods, than would be the case under less dense conditions. Unless deliberately started within a forest, planted and maintained at proper density, a fire cannot enter such except at the margins, and even if so entering can much more easily be coped with.

The great safeguard that dense planting affords has the advantage that it not only costs nothing, but at the same time the density of planting is all to advantage in the production of high grade timber.

Forest margins and fire-resisting species.—Whilst a fully stocked, dense, even stand is a considerable safeguard against fire, such a stand, if of a judicious mixture, is a greater safeguard. The intermixing of fire-resisting species with those which are not so, is advisable where conditions permit without disadvantages.

The planting of fire-resisting species as a narrow belt along margins, especially outer margins, is most desirable where soil and other conditions and the composition of the plantation make such a course reasonably practicable. The planting of some species which will naturally or then with no great attention maintain a sufficiently dense outer face right to the ground, to afford such shelter as to prevent entrance of the wind into the plantation, is also very desirable.

However, it must be understood that such a course as the latter, however desirable, is in many cases impracticable for various reasons. The soil and general conditions of the situation, whilst being favourable to satisfactory growth of the species of which the plantation consists, may be quite unsuitable for a fire-resisting species that would otherwise answer the purpose desired. Or any fire-resisting species that will thrive in the situation may be too slow growing, compared to

those that compose the plantation, to be able to maintain sufficient vigour to be of any service.

Amongst the species that are most suitable for afforestation purposes in southern lands there are not many that are really good fire resisters. The following, some suitable for margins, some both for margins and internal mixture, and some for internal mixture alone, are fair to good resisters:—

Black, Italian, and other Poplars, Cupressus Lawsoniana, C. macrocarpa, Redwood (*Sequoia sempervirens*), Canary Island Pine (*Pinus Canariensis*), Black Wattle (*Acacia mollis*), Blackwood (*A. melanoxylon*), and several other Wattles.

Besides being very beneficial in mixtures, the Black Wattle and the Blackwood are very excellent safeguards as marginal lines or belts.

A narrow belt of Eucalypts or Acacias—*A. mollis* or *A. normalis*, for instance—along the margins of a pine or other inflammable kinds of plantations is a great safeguard if the ground surface beneath is kept clear of dead branches, twigs, etc.

Many trees which, if grown with plenty of room, naturally assume a pyramidal form, will, if grown independently or on a margin, retain their side branches alive right to the ground for many years, or even right to the end. The reason for this continued growth of lower branches is that the form of the tree, each succession of branches being shorter than those immediately below, permits direct sunlight to the lower branches. Lawsoniana, Redwood, Macrocarpa, and to an extent Muricata, are of this type, and make excellent natural dense fire-resisting wind barriers on forest margins. Other species which do not naturally maintain continued growth in their lower branches, may be made, without great expenditure in labour, to continue dense green growth right to the ground, by shortening back of the upper branches so as to prevent the obstruction of direct light to the lower ones. Even the natural tendency of the Macrocarpa can be improved by being so treated. The Insignis though, through its natural form of growth, inclined to very soon become very open, can, if the outer face is cut back from the time the trees are three or four years old, so as to be kept slightly sloping inwards towards the top, be made to form a complete dense green wall that will, if kept clear of inflammable material at the base and inside, be quite fire resistant and at the same time be an effective wind break.

When cutting back, especially in the case of the Insignis, care has to be taken that none of the branches are cut back so far as to remove all the growing twigs. To ensure that this is properly done a slightly extended growth will have to be left at each cutting so that the green face will gradually extend outwards.

In many situations the species of which the plantation is to consist will require, if the growth of tall straight timber is to be ensured, outside shelter, therefore such barriers as indicated would serve the treble purposes of fire barrier, wind break for the trees, and preventing the wind driving under the trees and carrying a fire along the forest floor.

Fire-breaks.—Sometimes termed fire-lines or fire-traces. When deciding on the position of the fire-breaks it has to be borne in mind that fires burn most fiercely in exposed positions and up hill sides, advance with great rapidity up hill with the wind, and slowly down hill, especially slowly down hill against the wind. So the quarter from which the strongest winds blow and the inclination or various inclinations of the country are important considerations.

In the case of level or practically level land the whole area of the country can be cut up in regular main divisions separated by wide open breaks, and these again subdivided into smaller regular ones separated by much narrower breaks, which may or may not be open overhead.

The size of the main and smaller subdivisions, and the width of the main and the narrow breaks, should be proportionate to the risk of conflagration. This will depend upon the prevalence of high winds, the dryness of the climate, and the nature of the plantation, and the species of trees.

With any reasonable precaution fire in damp or in calm weather should cause little anxiety, but obviously fire in dry weather and during a gale or high wind is a very great danger, and therefore means for coping with fire under such latter conditions are what have to be aimed at.

As has been stated a properly densely planted forest can only, unless deliberately set on fire, be attacked by fire by entry on the margin, and unless properly attended to the margins are usually the most easily set on fire. If one block of the plantation is fully on fire in a gale even a wide clean break will not check the progress of the fire if the margin of the block immediately to the leeward is not clean. Fire fighters

cannot, when a gale is blowing, work in an open break to the leeward of a fire to prevent a fire catching the opposite margin.

Narrow breaks with clean margins are far preferable to wide breaks with neglected margins, and fire fighters can work effectively under the shelter of the trees within a clear margin, preventing or suppressing any outbreak within the plantation.

Though in localities subject to extreme dryness, and exposed to strong winds, and in cases where the plantation is of distinctly non-fire-resisting species, wide breaks may be desirable, clear breaks of from twenty to thirty feet wide with on both sides the ground and the trees kept clear of all inflammable material for about twenty feet back within the plantation, would usually be sufficient for most main breaks, and about twelve feet similarly treated for minor breaks.

Treatment and maintenance of fire-breaks.—Notwithstanding the very common acceptance of the idea and practice followed, even by some State Forest Services, in reliance on the width and cleanness of the break itself being a security against fire, it should be realized that at times of real danger from fire, that is during dry periods and high winds, a clear break alone, without a proper condition and care of the plantation face, is very little and frequently would be no protection at all.

The danger point is the plantation's face, and increasing the width of a break simply moves the danger point so much further from the centre of the break, and somewhat further increases the distance between two plantations. It has been proved over and over again on innumerable occasions that open supposed fire-breaks in certain places, no matter how wide, in cases of fires during high winds—and that is the time of danger—have not only failed to be of assistance but have actually increased the facility with which fires have extended through the large opening in the forest caused by wide breaks greatly increasing the effect of the wind in carrying sparks and flames, and exposing the whole face of the plantation opposite the approach of the fire to the full force of the wind. Under such conditions a surface fire, otherwise controllable, is frequently converted into a general conflagration—surface and crown fires.

Frequently under such a system of supposed fire-breaks fires have, in a high wind, jumped right over wide fire-breaks, not even setting alight to dry material ready to burn along the

centre, and even over a metalled public road plus fire-breaks on either side, and setting fire to the whole face opposite.

Exclusion of the wind as far as possible, narrow sheltered paths clean of anything that will burn, also with margins on both sides with both ground and trees clear of inflammable material, and sheltered conditions for the fire fighters are the general conditions that should be aimed at.

In undulating country open fire-breaks on ridges or other elevations are undesirable, but in such situations clean narrow covered lines on both sides of the elevation, some little distance down the sides, are advisable. From whichever direction the fire is approaching the clean covered line on that side can be used as a first line of defence, whether the endeavour be to extinguish the fire there or to use it as a line from which to back-burn, according to the nature of the fire, and the clean covered line on the leeward slope provides a second line of defence where the fire would be burning down hill.

A fire can be much more easily coped with in open breaks or clear covered lines along depressions, and also where it is descending an incline, than it can be on a ridge or other elevation. Further, a much less width of break is far more effective than that of an open break on an elevation.

The wider the fire-breaks the more costly they are to maintain, the greater the quantity and the stronger the growth of material on margins, the more exposed to the winds and the more exposed and hampered are the fire fighters. Further, the wider the fire-break the greater the area of land wasted and the greater the deterioration of the grade of the timber of the marginal trees.

In narrow covered lines once the canopy is formed weed and other low growth gradually fails, and soon ceases altogether.

Subject to the local conditions, the situation of the break and its size, it may be maintained by, in addition to keeping the faces trimmed and dense and the margins cleaned well back of all inflammable material, grazing sheep or by ploughing periodically either the whole width of the break or a strip on either side and keeping the middle burnt off, or by keeping the whole width of the break burnt clean, all dry material from the margins being taken well out on to the break to burn.

Burning lines.—Burning off on fire-breaks or any burning of material on fire-lines should be done only in moist weather, and usually only towards and during the evening, and only when there is no wind and no indication of it.

When such burning operations are being carried out there should at all times, without any exception, be complete organisation with ample hands to cope with any possible escape or threatening spread of fire.

Fire fighting.—According to the description of the fire, its strength and extent, and its position, including its relative position in the plantation where the outbreak is, and to other blocks of plantations, the position of the line of defence that should be taken up should depend.

The actual fighting—full organisation being assumed, as an essential precedent—may be with water, by beating, by use of explosives, or by back-burning. Some one or more or all of these means may be necessary. Obviously the more complete the organisation is, as to men, appliances, transport and training, the more effective will the efforts be.

Very generally water has been applied only by use of jets, buckets, and such like, and much reliance has been placed on beaters, both in dealing with outbreaks and when burning off on breaks, lines, etc. Such methods require proportionately very large number of fighters.

Of late other methods are being adopted in places, and should be generally, for they quite revolutionize the means of fire fighting, at least so far as the greater number of fires that have to be dealt with in connection with plantations, as affecting the use of water, and the work of beater, and the number of men required.

Water applied in a fine strong spray has proved, in all such work referred to, to be enormously more effective than if applied by means of a jet, buckets, or such like. It would not be an over statement, and possibly a much under statement, to say that a gallon of water applied by means of a fine strong spray would be more effective than fifty gallons applied in the form of a jet, or than if splashed on from buckets. In suppressing or isolating separate outbreaks, in suppressing grass fires, and when attacking a fire along its margin, or when back-burning, when control as to fierceness, too rapid side extension, and for protecting the rear and also for safeguarding and control while burning off on fire lines two men with first-class strong fine knapsack sprayers will do more than twenty beaters, and will run less risks and suffer less from fire or smoke.

It is more than surprising what effective and extensive work can be done with comparatively few gallons of water.

For instance, in the case of a fire approaching a narrow covered fire line through a plantation, two sprayers or sprayers in couples can pass along the line, one sprayer spraying the ground, the trees, and the advancing edge of the fire on the fire side, the other spraying the ground, the tree trunks, and up into the branches possibly on the other side of the line—that is the side away from the fire, resulting in complete and final stopping of the fire.

In such a situation—a narrow covered line—no wind or practically no wind enters, and the fire burns straight up or nearly so with very little forward drive, and so can be attacked at quite close quarters by the sprayers without risk. This is particularly so when the lines are in depressions, where they ought chiefly to be, and not on ridges.

An ample supply of water ought to be available close and of easy access for all fire lines. As natural supplies will seldom if ever be of sufficiently easy access except at a few points, drums kept filled with water should be established at comparatively short intervals on all fire lines. Small drums, say 10 to 20 gallons, at short intervals are much better than larger drums at longer intervals.

The great advantage in the use of water in the form of a fine spray over its use by means of a jet or splashing is due to two distinct causes. First, as to the application by jet and such like, a large quantity is used in striking very small points and through weight and force is soon dissipated, immediately running off whatever it has struck. On the other hand, in the case of a strong fine spray a very small amount of water is widely spread over the whole space, covering everything in detail with fine globules of water that do not run off but remain as such, as in the case of a heavy dew or mist. During the actual spraying the fire is screened as if by a thick, dense wet blanket.

Prevention and detection of fire.—Judging by experience, enlightening of the public as to the risk of starting fires, and to the immense loss yearly caused by fires, and the awakening in them of a conscience as to their duty to, at all times, take every possible care to prevent the starting of fires, seems almost a hopeless task, but still all means possible in that direction should be taken by all State and other authorities, and by the Press.

Entry by any but authorized persons within the confines of afforested areas ought to be absolutely prohibited unless it

may be that there are some particular areas so tended and guarded that no risk is run, and that all who enter are under observation.

Especial precautions should be taken along margins abutting on public roads and any parts where there is much likelihood of trespassers entering the plantations.

In connection with plantations of any considerable extent look-out stations should be established in such positions as will command the most extended view of the plantations, and the easiest possible access should be provided.

In the case of extensive plantations provision should be made so that a continuous look-out is kept, and for telephonic connection. When the plantations are not large enough to warrant a continuous look-out being kept, it is most advisable that provision should be made for such during any exceptionally dangerous periods. Failing either of these courses the look-out station could be hastened to on there being any indications of fire in or near the plantations so that its position, etc., could be readily observed.

Provision should be made for rapid gathering and transport of men and tools to the point of any outbreak of fire, and general organisation of as strong a body of fire fighters as possible, and instruction given as to the most effective way of combating each class of outbreak.

Fire being the greatest of all dangers to the forest, and the cause of immense losses every year in most countries, there are hardly any measures too stringent or precautions too great for foresters or forest authorities to take.

Chapter XXXI.

DISEASES AND PESTS.

Broadly, indigenous trees in each country or division of a country to which they are chiefly confined, representing, under the special climatic and other conditions of their natural habitat, survivals of the fittest, are more or less immune from the ill effects of various fungoid and insect troubles. And some species continue to thrive in full vigour, as in the case of some of the Spruces and Pines of the zone of Spruce and Pine belts

in the north, though growing in continuous "pure stands." Many other species continue to so thrive in warmer zones, but mostly in general mixture. But experience has shown that attempts to grow many of these trees in warmer climes and other countries have resulted in their being attacked, sometimes disastrously, by diseases and insect pests, esspecially so when grown in "pure" plantation. For instance, the removal of pines and spruces from the northern zone to Southern Europe, and also the planting of the same species in New Zealand and other lands, has been followed by disastrous results. Species of Spruce have almost been wiped out in the milder parts of New Zealand, and the Pinus sylvestris is practically not worth attempting to grow because of its lack of health; the same applies more or less to many other species which thrive vigorously in their natural habitats.

On the other hand there are many species which, though transplanted very far from their natural homes, and this applies to trees from both hemispheres, continue so far to thrive satisfactorily.

Many valuable forest trees from the Northern Hemisphere, notably such as Insignis, Redwood, Oregon, Lawsoniana, Macrocarpa, and many others, display extraordinary vigour and rapidity of growth in their new home in southern climes. Most of these make most extraordinary growth in New Zealand, many of them do so, though to a somewhat lesser extent, in Australia and South Africa, but in none of these countries are they all entirely free from various troubles.

In two instances, those of the Insignis Pine and C. macrocarpa, this extraordinary vigour of growth, which would suggest a re-starting of the life of the species, is the more remarkable from the fact that in their natural habitat, which is confined within very restricted limits, both species are affected by disease, and are apparently dying out.

This knowledge should be a serious warning against undue reliance being placed on the continuance of the remarkable vigour they display in their new homes, and especially should it be a warning against the risk incurred in planting in "pure stands" over great areas.

As mentioned earlier the greatest invitation to disease and insect pests is "pure" planting, and the more extensive such planting the greater the risk.

Every authority on forestry who deals with the matter at all agrees that the greatest resister and preventer of spreading

of disease and insect pests is "mixed" planting. Of course, in stating this it is assumed that the species planted are suitable to the situation.

Although already referred to in the chapter on "Pure and Mixed Stands," the question of the great invitation that "pure" planting extends to disease is of such vital importance that repetition here is advisable.

Sir William Schlich says:—"Only a few species are fit to be grown in pure woods."

And further, to quote from a recent issue of *Nature*, an English scientific journal:—"The planting of pure blocks of rapidly growing exotics is in many parts of the world to court disaster in the long run in one form or another, more especially when the behaviour of the exotic from a sylvicultural point of view in its new environment is by no means well understood."

In none of our southern lands have exotic forest trees been grown long enough under any conditions to afford material for the formation of an opinion as to what species, yet unaffected, may be or are likely to remain disease resisting, nor to what degree different sylvicultural systems and practices or repeated cropping may be a modifying influence on their vitality. On the other hand, unfortunately, under the most favourable sylvicultural condition many species have weakened, some to the extent of practical extinction, under the conditions they have met in their new homes.

Next to and in conjunction with "mixed" planting, vigorous growth is a great resister and thrower off of these troubles.

Therefore it follows that "pure" planting should either be avoided altogether or then indulged in to the least degree, that the best climatic and soil conditions should be sought, that the most careful selection of species most suitable to the situation should be made, that only plants grown from seed from selected best type trees, growing under climatic and other conditions as nearly as possible similar to those where the plantation is to be raised, should be used. Further, none but good sturdy, carefully-handled plants should be used, and that the land should be of quality and properly prepared, so as to ensure rapid healthy growth.

There are many instances within the writer's experience where, through some unfavourable conditions such as an unseasonable dry period, growth practically throughout a whole young plantation has been retarded, followed by seemingly serious attack of pests, but which has been entirely thrown

off, on the young trees regaining vigour in growth. Also instances of plantations which have been established where the surface soil conditions were unsuitable to the healthy growth of seedlings and young plants, and consequently they were long in becoming thoroughly established, and as a result were for some years badly affected, but later, as the roots got down and vigorous growth was established, all trouble, with possibly a small percentage of exception, was thrown off. On the other hand there are many instances of plantations, in which the trees have reached much of their full height growth, being badly checked by some unfavourable conditions, such as possibly lack of thinning, or by their roots reaching hardpan or a too wet stratum, or even perhaps as a result of improper treatment of the roots in the nursery and in planting preventing the development of a sufficiently good root system to support the growth of large trees, and as a consequence of lack of vigorous growth, disease and other troubles have set in.

Among the many seemingly immune exotic trees that have for long thriven with surprising vigour in New Zealand from time to time there occur instances of species being badly or even fatally attacked by disease. Among such instances there is that of the Spruce, and quite recently that of the Black Wattle (*Acacia mollis*) which, though hitherto showing extraordinarily vigorous healthy growth in New Zealand, has now been very badly attacked by a cankerous growth which is rapidly spreading throughout the country, and from which vigorous growing young trees can, up to nearly the age of maturity (10 years), suffer not greatly but which is, later on, absolutely destructive.*

The condition of the forest floor has a great bearing on the sustained vigour of tree growth. It is important that the canopy closes in as early as possible (for this, dense planting is one essential) because with the closing of the canopy conditions most favourable to tree growth and the more rapid building up of the forest floor are established, but as growth proceeds a proper degree of thinning must be carried out from time to time, so that no undue check to growth will be sustained through overcrowding above or below ground, and though leaves and small *débris* are necessary for creation of humus, no dead or dying trees or any large dead wood should on any account be left in the forest, for such becomes a breeding ground for fungoid and insect pests.

*NOTE—The writer has since found and brought to notice the fact that Acacia Mollis, grown in mixture with Eucalypts, shows a complete freedom from disease, which fact provides further evidence of the soundness of the principle of mixed planting as the greatest preventive of disease.

This work of keeping the forest clear of dead wood can be carried out certainly without loss, and likely at a profit, in the case of suburban and other forests located in or near closely settled parts, but it is one of the great disadvantages in the case of remote forests, for from such no use can be made of any of the material—thinnings or dead wood—and therefore the prohibitive costs of removal of such to entire waste enforces complete neglect of the work, which, added to such forests being in most cases "pure" planted and covering large areas, makes the risk of disastrous attacks of disease and other trouble very great.

Whilst detection, treatment, and cures of various complaints and pests are all subjects of present investigation and research by various institutions, both State and other, in all our southern lands, and valuable information as to means of dealing with and combating these troubles is, and will from time to time become available in each of the countries, the wholesale "pure" planting over great areas of practically one species cannot be characterized other than as a dangerous invitation to trouble if not disaster.

The risk of disease and other troubles is largely with introduced species; and unfortunately practically all afforestation in southern lands, with the exception of use by Australia of its Eucalypts and Wattles, is with introduced species. All the species used for afforestation in South Africa are introductions from northern lands and from Australia. Every single species used for that purpose in New Zealand is introduced, as none of the indigenous forest trees are suitable for practical economical timber production by means of afforestation. Considering the foregoing, it must be fully recognised that afforestation, though greatly favoured by natural conditions in our southern lands, will always be subject to much greater liability of loss or disaster through ravages of disease and pests than is the case in northern lands where indigenous species are more generally used.

The more extensive our plantations, especially of "pure" pine, and with the advent of re-cropping, the greater will the menace become, therefore it behoves all concerned to do everything possible to promote natural resistance by following sound practices as the surest safeguard in the first instance, whilst vigorous research work as to the best means of combating diseases and insect pests is carried on by State and other institutions.

Chapter XXXII.

DESTRUCTION BY ANIMALS.

In some countries there are certain areas of what may be termed forest-lands, where the open or sparsely planted condition, and the species of the trees growing, permits the growth of a considerable amount of pasture. In such cases benefits may be gained by depasturing large cattle within the forest. Trees of some species when grown widely spaced are less susceptible to injury to their roots by stock, and as the over open planting will have prevented any appreciable building up of the forest floor the treading of cattle will make little difference. On the other hand the grazing by cattle under such conditions will keep down excessive growth of grass, and thus, among other things, lessen the risk of damage by fire.

But generally speaking cattle of all kinds should be rigorously kept out of plantations at all times.

Different kinds of cattle injure the trees and the forest in various ways and in different degrees. In young plantations cattle of all kinds will push over and break the young trees or their branches, rub and eat the bark and twigs, and as the plantation gets older injure the forest floor and seriously injure the roots of the trees. In practically all cases plantations where cattle are allowed in will suffer serious injury, and the growth of the trees be greatly retarded.

Grown large cattle are on the whole less injurious than young and small cattle. Deer are bad, sheep are very bad, especially in young plantations, the young trees suffering very greatly from their rubbing. Goats are far the worst, and generally are absolutely destructive in many respects, such as in case of young plantations, for a considerable number of years, and of re-growth and regeneration.

Opossums and other tree-climbing animals are not a very serious trouble unless they are in great numbers.

Hares and rabbits are both very bad, but hares are a cause of very great worry and loss in quite young plantations, and in the case of re-growth or regeneration. They are excessively troublesome and destructive in the nursery, both in the seed beds and among the young plants.

In some places where they are very plentiful it is more profitable to completely enclose the nursery with suitable wire netting.

Towards keeping the number of hares down—it can hardly be hoped to get rid of them—trapping is probably the most effective means. Hares cannot resist the temptation of carrots, and so that bait for the traps may be provided, and with the object of attracting the hares to certain points, it is advisable to grow plots of carrots, within wire netting, in different places, and from time to time throw a few carrots over the wire on all sides for some time before setting the traps.

One plot of carrots should be grown either in a corner inside the nursery, or better still, nearly against the outside so that the nursery wire boundaries will act as a lead to the traps.

If hares are numerous they must be dealt with seriously, even if much trouble and considerable cost is entailed, for besides the great damage they will do in the nursery, that done in the new plantations is exceedingly difficult and costly to partially, and frequently quite impossible to wholly, repair.

For coping with the hares over a considerable area within which the nursery is situated, the following is an efficient method:—To grow at one end of the nursery, as indicated on Plan 1, a patch, enclosed in wire netting, of carrots slightly away—say about 6 feet—from the direct line of the nursery wire netting fence, making leads as shown at the points A and B on Plan 1. In such leads either traps could at times be set, or much better than traps would be to so place the ends of the wire netting at A and B as to permit of hares just being able to enter at either point but not to permit of them returning. This can easily be done by, whilst fastening the ends of the wire at the top, carefully adjusting the lower part so that it would give sufficiently to allow entry but would close on the slightest touch during attempt to get out. By such means if traps are not used quite a number of hares, many from one lead or the other, enter, be retained in the enclosure, to be shot or otherwise disposed of in the morning. Whilst if traps were set one hare might be caught and numbers so scared away as to be made too shy to be attracted there again.

The wire netting fences all round the nursery, around which the hares would travel looking for openings, would act splendidly as leads to the carrot patch and the leads into it.

Chapter XXXIII.

PRODUCTION OF HIGHER CLASS TIMBERS.

So far only comparatively short rotation periods have been taken into consideration in the preceding chapters, and the importance of choosing fast growing species, the wood of which will reasonably answer the purpose for which it is required, preservative treatment being resorted to if necessary, in preference to planting species which are slow growing but the timber of which is much superior.

Undoubtedly such a general course is economically sound, but nevertheless every country will require for some special purposes a greater or less proportion of various classes of timber of the very highest quality. The needs may include any of such qualities as great strength, durability, beauty, or any other qualities or combination of qualities that are specially required.

If natural supplies have, or are likely to, run out in any country, and if there is no assurance that they can be obtained from other countries, then it is obvious that if possible species of trees that will provide such high qualities of timber should be grown to some extent even if very costly to grow.

With some few exceptions of some species that grow fairly rapidly and yet produce timber of high quality, it is certainly true of far the greater number, that if grown under such sylvicultural conditions as would ensure the production of the highest grade of timber, the rate of growth based on the cubic content, will be very slow, in other words the rotation period will be long, very long, compared with fast growing trees.

Long rotation periods impose, if they cannot be met by early crops of some sort, exceedingly heavy charges, of first costs and maintenance charges compounded against the forest. The amount of forest capital per acre increasingly grows very large.

To form some opinion as to the comparison between such accumulated charges on slow growing and fast growing crops, it may be assumed, and fairly so, that from 35 to 45 years—say 40—is about the period required for some fast growing trees to reach reasonable maturity—that is when their timber

will be near its optimum in quality. On the other hand many species of slow growing trees, which would include in their number those which it would be necessary to grow for the purposes suggested, would take from twice to several times as long before their timber would anywhere nearly approach optimum quality. But if the period of 80 years is taken in one and 40 years in the other case and in both cases first costs are taken at £15 per acre for land and establishment combined, and 10s. per annum maintenance, both compounded at 5%, the position as to accumulated charges per acre, assuming that in neither case had these charges been met by earlier crops, would be as follows:—

40 years—£166 per acre accumulated charge.
80 years—£1,228 „ „ „

Even if the total first costs in land and establishment was as low as £10 per acre, the total accumulated charge would amount to respectively £130 and £980.

Besides this great disparity the disease, fire, and other risks are extended over the much longer period of 80 years.

It is obvious that in face of such a position earlier returns from thinnings or from intermediate crops must be aimed at.

As has been shown earlier this can assuredly be secured in the case of fast-growing species, or even to a certain extent with the few moderately fast-growing ones that produce high quality timber, in near market or suburban forests, but not in remote forests. But the problem is quite a different one in the case of at least most of the slow-growing species, for the reasons that a plantation of slow-growing species will not in a short time produce anything of sufficient bulk to be at the best of greater value than the cost of getting it out and of marketing, and there are practically insuperable objections to, in the first instance, growing fast-growing species, which would produce early returns, in mixture with slow-growing unless the slow-growing species is a distinct shade bearer and the fast-growing one not a light obscurer, but the disadvantage under such conditions is that the slow-growing species would not be growing under sylvicultural conditions that would result in highest grade of timber.

One way of dealing with the problem presents itself, and that is to obtain the required density for the slow grower by filling in with some temporary nurses, and later, after the slow growers had attained considerable height gradually removing

the nurses and replacing them immediately with fast-growing species that will bear the amount of shade that they will be subjected to. Such fast growers might produce a fairly profitable intermediate crop. But at the best it is a problem not easy to deal with.

On the other hand, so far as such moderately fast growers which produce high quality of timber there are two or three courses which may be pursued, one of which is being put into practice, under the advice of the writer, in the plantations of the Taranaki Forestry Company near New Plymouth, New Zealand.

Presuming that proper sylvicultural practices will be more widely adopted, and that as a consequence much higher grade timber will be produced from fast-growing trees, and that increased durability will be, where required, produced by more general use of preservatives, the proportion of high quality timbers required will be quite small. In other words, only a very few slow-growing trees would need to be planted to the great numbers of fast growing.

Many fire-breaks are better as covered breaks than open. That is, instead of being open and therefore exposing the forest margins to the full force of the wind, they be simply broad or narrow strips, through certain parts of the forest, where the forest floor and the trees are kept absolutely clear of all inflammable material the trees occupying these strips, under some circumstances, and also those occupying more or less wide portions of some of the forest margins, may consist of species that produce high quality timber. Both such breaks and margins may be retained as wind breaks and protectors of the forest floor, and of the second crop, when the plantation of faster-growing trees has been felled, removed, and is being replaced. Further, any over steep ravines from which the removal of material would be costly could be also planted with slow-growing species and treated, or at least a portion of their breadth, as permanent fire-breaks.

In some parts of New Zealand, especially where the rainfall is heavy, unimpaired native bush is distinctly fire resisting in ravines, though not necessarily so on elevations, rising, or level land.

The Taranaki Forestry Company's plantations, which occupy comparatively even lands, are in parts divided somewhat by sharp narrow ravines in which the native bush has

been preserved. These have proved absolutely reliable fire-breaks, and are of very great value as such.

The margins of these and parts where rather open, are being planted with species that will take longer to mature than those in the general plantation. The cost of such planting and of any care it needs will be much less than the cost of maintaining open fire-breaks, and therefore the slower maturing species will be a means of saving expense instead of building up a charge whilst they are growing into a valuable asset.

There is still one other course open by which species requiring a very long period to mature may be grown without excessive costs accumulating against their produce. That is where afforestation for climatic or protective or reclamation purposes is necessary in places that are too inaccessible at the time of planting, and likely to remain so for a longer period, for afforestation for ordinary purposes to offer any prospect of being remunerative. In such cases the costs of establishment and maintenance would be fairly chargeable against the primary object—protection or whatever it may be—and not against the produce that may later be obtained.

Under the same category comes under-planting or reinforcement of any more or less inaccessible native forests which it is intended to maintain for the same purpose as just referred to.

And lastly, the course of ordinary under-planting of well grown stands with such of the moderately fast-growing species as are sufficiently shade bearing. This will be dealt with in a later chapter.

Chapter XXXIV.

SOME FACTORS AFFECTING THE QUALITY OF TIMBER.

Unfortunately many who in the past had control of forestry operations (some of these extensive State or other undertakings), and others who have been interested in tree planting, have simply depended upon the general repute of species of trees, without taking into consideration the great differences in growth and in the qualities of timber in local variations mostly due to soil conditons, and who, having chosen certain

species, were either unaware of, or placed no importance at all upon, the great effect the lack of proper sylvicultural treatment has on the various qualities of the timber.

For timber purposes it is often far more important how a tree is grown than what species it belongs to.

Of course the first thing for the forester is to find out what species of trees will grow well in the particular situation and then of those what species will produce timber reasonably suitable to the market or the particular purposes required. He should then from these select such as will grow fastest. His next care should be to secure seed of these from the best type trees, of the particular variety that has been proved to produce the best timber, grown under as similar conditions as can be, to those where the seed is to be grown.

Sylvicultural treatment.—Knowing the purpose for which he is going to grow the trees the forester will so plant and generally submit them to such sylvicultural treatment as will best ensure growth, to suit the special purpose aimed at, but to do so without ignoring the importance of fire, disease, and other risks, and soil preservation.

If the purpose be for case timber, as case timber requires to be light, free from loose knots, only moderately strong so long as it holds nails well, and requires neither density nor durability, the trees will be so spaced and in such mixture as will ensure rapid height growth and early elimination of side branches. Later from time to time such extent of removal of nurse or other trees would be carried out as will give full room for rapid diameter growth.

If on the other hand density and strength is required, a species that will produce such timber should be chosen, and the sylvicultural treatment should be such as having secured height growth and long clean boles the density of the stand should be maintained sufficiently to permit of only slow steady diameter expansion.

If great strength and durability is required not only should species which are capable of producing such timber be chosen but the lessening of the density of the stand should be still more gradual and maintained much longer.

By improper sylvicultural treatment many species have been given a bad reputation that they little deserved. This is much more likely to occur to a greater extent with exotics in countries or particular districts where the climatic and other conditions favour very rapid growth.

The timber of the Insignis pine, which is really a very excellent timber for many purposes, has, through being grown under improper sylvicultural conditions, been given the name of being very knotty, coarse-grained inferior timber.

The timber of the Redwood which, though under no conditions a strong timber, but a most valuable and durable timber, in fact one of the most valuable, has been branded in New Zealand—New Zealand grown—as suitable for case timber. The timber of trees grown under absolutely improper sylvicultural conditions, and showing a diameter growth of one inch to the year was tested for comparative strength purposes with American grown timber showing one inch diameter growth for *nine and a half years.*

The timber of certain species of Eucalypts grown in certain places has been as unjustly, and it might be said as ignorantly, condemned, because the timber of trees grown improperly, showing a diameter growth of 12 to 16 inches in twelve years, has been compared in strength and durability, bulk for bulk, with that of trees which have taken forty or more years to attain the same diameter.

It is impossible to stress too much the great bearing that sylvicultural treatment has on the various qualities in timbers.

It might hastily be judged that sylvicultural treatment that would retard undue diameter expansion would do away with the advantage that might be gained by conditions of a situation that causes rapid growth.

Such is by no means the case because, leaving out of consideration any other advantages, rapid height growth with proper density in the stand, gives a very much greater length of bole quickly, with very little, if any, taper, around which the annual sheaths will be built absolutely clear of knots.

The situation has a great effect on the quality of the timber and therefore, as far as possible, species most suitable to the situation should be chosen.

Chapter XXXV.

AT WHAT TIME OF LIFE SHOULD A TREE BE CUT.

Involved in the question at what time of life should a tree be cut are several others, chief amongst which are (1) at what period of the life of the tree will its timber be of the highest

quality, (2) at what age does the annual increment cease to warrant delay in cutting, (3) what is the market value, (4) what class of plantation, "pure" or "mixed" should be established, (5) what species planted, and (6) what sylvicultural treatment is best.

Without sound opinions on such questions reliable working plans cannot be prepared.

The essential need of close planting has been emphasized repeatedly, and also the almost equal importance of repeated thinning throughout most of the growing life of the forest.

It is obvious that in the case of "pure stands" the material removed as thinnings must be immature, and much of it, especially that of the earlier thinnings, over young. Such forms one of the forester's chief problems, and in solving it "location" is the main factor, and the species of the trees the next important.

Broadly speaking the younger the trees the poorer the quality of timber they yield, and the more restricted the number of uses to which it can be put, as it will be small in size, not always durable, soft, and not strong. There are some exceptions to this general rule.

In the case of "mixed" planting the forester would, in deciding on the composition of the mixture, as far as possible so select as to provide that the earlier thinnings would be of a species that produce material that could be marketed as small round wood.

It is clear that whether the plantation is "pure" or "mixed" the sylvicultural needs are the deciding factors as to when cutting by way of thinning should be made and not the quality of the material to be removed. Therefore the question as to at what time of life should a tree be cut, affects only the selection of the mixture and the main crop.

First, as to age.—The timber of a tree reaches its optimum of quality approximately at maturity. A tree reaches maturity when, if growing in a fully suitable situation as to soil conditions and depth and as to climatic conditions, and if it has ample room but not subject to undue exposure, and if nothing has occurred to unnaturally check its growth, it ceases to gain height, and its branches cease to extend, and a very decided decline in rate of diameter growth takes place.

An absolutely definite age at which trees of any species reach maturity cannot be fixed, for it will vary somewhat in

different countries and under different conditions, but the experienced forester will detect the signs of maturity.

The quality of the timber does not greatly vary, at least that of most species, during a period of some years—short or long according somewhat as the length of the life of the tree is short or long—before or after maturity, therefore there is a considerable margin either way within which the time of cutting can be selected to suit other factors.

Next as to increment.—There is a time which varies greatly with different species in its relation to the total average life and to the age at which maturity is reached, when, due to the decrease in the annual increment, it ceases to be profitable, from a yield point of view, to allow a stand of timber to remain uncut. When that time is the forester can ascertain.

For example, it will be presumed that the stand is an "even aged" "pure" stand and that the conditions throughout have been fully favourable, and that data as to volume growth has been recorded throughout, or at least during a period around the time of maximum annual volume increment.

If by the annual volume increments the peak year of growth is ascertained and the total volume of the stand at the peak years is divided by the number of years from the date of establishment to the peak year the average annual increment throughout those years, which may be termed the "years of ascent," is arrived at and noted; then when a time during the years after the peak year—which may be termed the "years of descent"—is reached when the amount of the annual increment falls below that of the average during the years of "ascent," the time has been reached when it is no longer profitable, from a yield point of view, to keep the stand uncut. But it may be that, in the case of certain species, especially where after the zenith has been reached a vigorous, though slightly declining rate of growth is maintained for a long period, and the timber may gain added value, through increased quality and size, that will compensate for lesser added annual increment.

Further to indicate how the time to cut from a yield point of view can be ascertained, a stand of timber, in its rate of growth and early maturity suggestive of Pinus insignis, may be presumed, which, in its 30th year had a total volume of 90,000 b. ft. per acre, and the increment in which for the last—the peak year—was 6,000 b. ft., which gives an annual average of 3,000 b. ft. per acre, and during the 15 years after the peak

year it is presumed the annual increment steadily decreased until by the 45th year it had fallen to 3,000 b. ft., the average increment for the first 30 years.

If such a stand is cut say in the 46th year and replanted, another period of 45 years of average annual increment of 3,000 b. ft. would be entered upon, whilst on the other hand if not cut there would be a steadily declining increment, from below the average of the 45 years, and therefore by comparison decreasingly unprofitable.

From the rapidly decreasing rate of increment in such a case it is clear that the termination of the highest average annual volume increment is not far from the time of full maturity of the stand, and therefore yield and quality both point to a rotation period of between 45 and 50 years as the best.

Such as indicated by the foregoing is the simplest, being clear of any problems as to very long life, long delayed maturity, or what may be termed undue inferiority of timber during a long period.

The Corsican pine is an instance of the latter. The Corsican pine, so much planted, especially by the New Zealand State Forest Service, because it is very hardy and not a very slow grower, but particularly because of its reputation as a producer of good quality timber, a reputation only warranted for the timber of trees of an age running into hundreds of years.

The Corsican pine takes a very long time to mature. A very much longer time than the time assigned to it in England as a rotation period, and during its earlier life, and for long carries an excessive proportion of sap wood, over 80% in its 80th year. This long delayed maturity indicates a proper rotation period beyond the reasonable calculations of a forester dealing with afforestation, for he would look to a species that would give a far greater yield of timber equal or superior in quality to that of immature Corsican.

As a further example another sequence of rates of growth, somewhat suggestive of that of the Redwood, may be taken.

Rather slow for the very early years followed by a period of 50 to 60 years or more of greatly accelerating increase in volume, and that followed by hundreds of years slightly increasing annual increment. How far the Redwood, for instance, in its natural sequence of rates and its rate of growth compares with those under afforestation conditions in our southern lands will not likely ever be known in full, but its

rate of growth for the first fifty years is known. No rotation period could be set for the Redwood on a maturity basis because maturity is so remote, but it is clear from the greatly increased rate of increment for such a number of years that the more prolonged a rotation period for it within limits, the more profitable. There is one point in favour of young Redwood—which is just the reverse of the Corsican—that is, that the timber if grown properly, though very far from matured and so necessarily less strong and less durable, is valuable for many purposes.

It is clear from the foregoing that there may be a great difference in the end of the period of highest average annual volume increment and the age of maturity, and also in other cases between the limit of a practicable rotation period and the age of full maturity, but in many cases a reasonable mean, when the available market is taken into consideration, can be arrived at by the forester.

So far reference has only been made to quality and volume increments as indicating the right time to cut, or in other words, as a guide to the proper rotation period, but there is what is known as the financial rotation period.

Financial rotation period.—Location has an all important bearing on this. It is obvious that if the location of a plantation is remote, or if it is so located that thinnings, small wood, etc., cannot be marketed as the years go on, the wood or forest capital, as it is called—made up of land costs, establishment and maintenance costs, rates and taxes, all at compound interest—goes on mounting up at such an increasing rate that the rotation period could not be extended much, if at all, beyond the peak year of annual volume increment because the annual additions to the forest capital would increase more rapidly than the timber increment. This one thing indicates one of the greatest indictments against planting in remote places.

On the other hand a forest properly located where intensive forestry could be carried on, as all material from it could be utilized, would have no charge accumulating against the main crop, and therefore that crop could be allowed to grow until the end of the period of maximum average annual increment and until the timber reached high, if not the highest, quality.

Chapter XXXVI.

USES OF WOOD AND THE KINDS MOST REQUIRED.

The uses to which wood and wood products are put are so many and varied—and they are constantly extending—that it would be tedious as well as useless to attempt to enumerate them, but as has already been mentioned the demand for softwoods, chiefly doubtless because of its use in the production of pulp, is already over 80% as against under 20% for hardwoods, and the proportionate demand for softwood is constantly increasing, consequently in the predicted, and undoubtedly truly predicted, coming wood famine, it is in softwoods that the greatest shortage is anticipated.

Hitherto the growing of pines has been looked to as the only means towards meeting the position.

The exceedingly slow rate of growth of pines, as well as other trees, in the Northern Hemisphere, indicates that our southern lands, where the rate of growth by comparison is so extraordinarily rapid, must be looked to as offering the only real prospect of provision for the future.

Pinus insignis.—Of all trees the world over the Pinus insignis stands out as one of the most rapid, if not the most rapid, and most adaptable and most reliable grower under very widely varying conditions in all our southern lands, consequently it is being far more widely planted in New Zealand, South Africa, and even in Australia than any other species, and very great and wonderful results are being anticipated from it, and this is very especially so as applied to New Zealand.

To the mind of the writer far too optimistic a view is being taken, and still far more incautious a policy is being followed.

Is it not wise to remember the common saying not to place all one's eggs in one basket in this connection?

The planting of tens of thousands and possibly hundreds of thousands of acres, in large areas contiguous to one another in "pure stand" of Pinus insignis, to the almost entire exclusion of other species, is most certainly placing all the eggs in one basket.

"Pure" planting always carries with it special risks, and "pure" planting of an exotic pine in large areas creates a distinct menace of disaster through disease and insect pests.

How very much wiser it would be to lessen this risk by planting some other species as well which would produce material suitable for the same purposes, and preferably not a pine, even if in each case "pure" planting was adhered to.

Timber for Pulping.—Take for instance growing for pulping. For that purpose the raw material must reach the pulping mill at extremely low cost. Hence, the rate of growth must be very rapid, the yield per acre, say about the sixteenth year, very heavy, the trees of such a nature that the handling cost and the percentage of waste handled is very low, and of course the cost of transport low also.

Insignis is suitable for pulping when about 16 years old, but at that age the yield is not heavy, the taper is considerable, and owing to the excess of branches the trees are costly to work and handle, and the percentage of waste is high.

Various species of Eucalypts have been tested, and proved to be suitable for pulping and for general use as softwood when young—about 16 years old. Conspicuous among such is, for instance, E. saligna, which is an exceedingly rapid grower, is hardy, its timber when young is soft and of light weight, and in situations suitable for it, which are many, its yield at 16 years of age is far higher than that of insignis, and probably higher than that of any other tree. When planted under a proper system it grows with long perfectly straight boles with little taper. The boles are very smooth and clean, being quite free from branches for the greater portion of their height; this, with the distinctly light weight, renders it very easy and of low cost to fell, handle, log, and transport, and also there is a minimum waste.

A stand of Saligna 16 years old has shown a volume, inside bark, of over 150,000 sup. feet per acre, which is enormously greater than ever could be shown by Insignis under the most favourable conditions.

Besides being highly suitable when young for most purposes for which softwood is required, the Saligna produces a highly valuable hardwood when older.

Several other Eucalypts which will grow rapidly and well under many conditions and in situations less favourable for Saligna are highly suitable for use as softwoods for pulping and other purposes, especially when young, and for hardwoods when older.

It has to be remembered that whilst naturally-grown forests naturally self-producing, so long as the haulage costs,

such as by water, are not great, are a source of very low cost raw material, the position is very greatly different where an artificially, and necessarily costly, grown forest is looked to as the source of supply. The stumpage charge must be enormously greater in the latter case. Further, because of the necessity for keeping costs low for pulping purposes "clear cutting" is necessary. Thinning or partial cutting only at one time imposes far too heavy a charge in cutting and logging against pulping material to offer any reasonable prospect, in our southern lands, of financial success when the material dealt with has to bear the added charge of being the produce of artificially grown forests.

Especially as "clear cutting" for pulping material is necessary, Eucalypts such as Saligna have the great advantage over pine, in addition to less costly handling in that immediate natural very rapid second growth occurs from the stumps. There can be no question that it is certainly advisable to plant Eucalypts for the production of softwoods, etc., where the situation is suitable for their growth, in considerable areas interspersed between the blocks of Insignis, so that the great menace of disease and pests to which extensive "pure" planted Insignis is subject to would be lessened, and also so that this class of wood would be available in case of disaster befalling Insignis, or be available as well as that of Insignis.

Chapter XXXVII.

FORESTRY IN RELATION TO THE DISTRIBUTION OF POPULATION, EMPLOYMENT AND INDUSTRY, AND AS TO BENEFICIAL USE OF LAND.

Distribution of Population.—In addition to the questions of employment and development of industries generally, the steady and greatly increasing drift of population from the country to the towns is one of the most vitally serious problems that not only the Homeland, but the Dominions also, are faced with.

A thriving rural population is essential to the welfare of the community, and is the greatest stand-by a nation can have. Just what proportion of population should be rural to that of

urban must necessarily depend upon many circumstances, among others as to whether the urban is concentrated in a few great cities or distributed over numerous comparatively small towns. But there undoubtedly is, under each set of conditions, an approximately balanced proportion that cannot, with regard for the vigour and general well-being of the people, appreciably be overstepped in the direction of a greater proportion of urban.

That the serious cityward drift of population that has been going on for long has brought about a very dangerous disproportion is very generally realized.

General commerce and far the greater number of industries tend towards concentration in large populous centres, which is the most undesirable. On the other hand, numerous small communities, though classed as urban, are not disadvantageous to the general vigour and well-being, especially if surrounded by a thriving rural population.

The opportunity that afforestation and all that it leads to offers in providing rural occupation, and towards checking the drift to the cities has been recognized at Home, and has been vigorously advocated by many and in many ways, and much of the increased interest and activity in afforestation there, is largely due to this recognition.

Although foresters and others have, in our southern lands, repeatedly voiced the importance of forestry in this connection there has been very little indeed, if any at all, practical recognition. Such afforestation and other forestry work as has been carried out has been almost entirely so with the object of provision of timber, and consequently neither the choice of location nor the nature of work has been in the least influenced by considerations of employment and distribution of population.

The various divisions of employment provided by forestry.—It has to be borne in mind that all the work that leads up to and is included in the actual producing, in the forest, mill logs and other raw material, and which represents employment within the forest is but a very small part of the employment and concurrent wealth which results from afforestation—or at least from intensive forestry in proper location.

In addition to the amount of employment within the forest there is first that which is directly associated with it—connected with or adjacent to the forest—which may be termed primary conversion and treatment, and there are further the many secondary industries dealing with treatment of and manufacture from timber direct, producing wood products

such as pulp and paper, and the innumerable wood by-products, which industries may be wholly or partly carried on at or near the forest. Employment in such industries and the wealth produced therefrom would necessarily be immensely greater, many many times over, than the actual employment given and wealth in raw material produced within the forest. Therefore any comparisons made, as to profitable use of land, to be of value, must take into account all directly resultant sources of employment.

Forests as compared with other use of land.—There is a very general conception that land cannot be as profitably utilized by growing trees as it can be by agriculture, general farming, or the production of wool and meat. This conception, though unquestionably correct as applied to a certain proportion of the area of a country, and particularly to certain—in some cases very large areas—is very far from correct if applied generally.

It may fairly be assumed that in using the term "profitable," beneficial employment of labour is meant. Labour cannot to any extent be employed unless the ultimate result of such employment will, directly or indirectly, be an economic gain, therefore the degree of beneficial employment that is afforded by any primary or other industry should be the gauge by which to judge comparative profitableness or otherwise of any such.

This has been taken as the means of assessment both on the continent and in Great Britain, but most of the data available deals with the actual degree of employment within the forest, as compared with that on land otherwise occupied, and not with the far greater amount of employment resulting from forest production, around or adjacent to it, or from secondary industries connected therewith.

A committee on Forestry in Scotland, on which the leading authorities such as Sir John Stirling-Maxwell sat, found that forests gave ten times the direct employment in the forest as did an area employed as sheep farms. The continental figures are somewhat in the same proportion, but the proportions for the Northern Hemisphere, on account of the very slow rate of growth there, is much less favourable to forestry than in our southern lands, where the rate of growth is from three to seven times or more that in the colder parts of the Northern Hemisphere.

The degree of profitableness of use of land for forestry as against other use must necessarily vary very greatly according to the particular circumstances. The most important factors are on the one hand (1) nearness, or easy cheap accessibility, to market, and (2) favourableness of the situation for tree growth, but more particularly for the good growth of such species as the wood of which will find the readiest market; on the other (3) the quality of the soil, the climatic conditions, and the location that favour, for instance, intensive production of other high valued crops or other use highly remunerative, and (4) the proportion of forest to that of agricultural or pasture-land or to both.

Proper location is undoubtedly the greatest factor in ensuring success in forestry operations and in placing forestry far ahead of most other productive uses of land in affording employment. Nearness to a market makes possible intensive forestry, ensures early returns and utilization of practically every bit of material grown, this means heavy production, much work in the forest, and much more out of it in the processes of conversion, treatment, and manufacture.

Where forestry is least profitable, if profitable at all, and where the use of land for such purposes compares least favourably with its use for other purposes is when the forest is in a location remote from the market or from water carriage. High class or intensive forestry cannot be practised under such condition, high grade timber cannot be grown except at prohibitive cost, and timber, being such a bulky and weighty material compared to its value, the cost of transport either makes it unremunerative to use any or then only the best, which due to the conditions under which it has been grown would be a somewhat small proportion. Such means a light yield and little employment.

The fetish of cheap land, which generally means remote location, has been so generally condemned by all authorities who have made reference to it, that it is extraordinary that it still holds a place.

If land in a very remote location is capable of growing any pasture it would generally be more profitable to spend the money on fertilizers or other means of improving it and use it for wool growing or stock raising than to spend the money in planting and growing a low class forest, the yield of which can at best be light, and the produce of which, owing to long costly

haulage, can be undersold by that of near located forests. Timber cannot walk to the market as cattle and sheep can.

There is another very important feature in connection with afforestation and employment.

Suburban forests, where intensive forestry can be practised, in marked contrast to remote forests, provide a great deal of employment in the winter time when other channels of employment are lessened, and therefore they are an important means towards equalizing throughout the whole year the utilization of labour.

Further such forests would afford in the forests and associated with them employment for classes of labour that are not fully fitted for many other kinds of work.

Another feature in connection with forest employment, in our southern lands especially, is that it is much more congenial work than most outdoor employment in the winter time.

A quota of forested land near centres of population and interspersed with agricultural and pastoral lands affords great benefits, climatic and otherwise, as well as the produce of the forest being available near at hand.

Chapter XXXVIII.

SELECTION OF TREES SUITABLE FOR AFFORESTATION IN SOUTHERN LANDS.

Most general works on Forestry contain fairly full descriptive lists of the complete range of species of trees which are recognised as suitable for planting in the particular country or countries dealt with. From such lists a very wide range of species have been chosen for afforestation in our southern countries, judged on their reputed merits as timber producers, and planted in large numbers without sufficient consideration, if any, being given to their comparative suitability for, or value in, their new homes.

This has led to very great waste of money, time, and opportunity. Of course that sort of thing is greatly, if not entirely, due to lack of qualified guidance in the conduct of afforestation operations, and the consequent assumption by the unqualified that, because certain species of trees in some situations or

countries produce timber of value, therefore they are species that ought to be planted, ignoring many things such as the possibility that their reputation may be due to the fact that in certain situations they are more suitable, just because they thrive where others will not. The result has been that second and third rate species, judged from the point of growth and also of quality of timber, have been planted by hundreds of thousands where first and second rate species should have been, and first and second rate species have been grown under such improper sylvicultural conditions that they can produce only third rate timber.

Unfortunately in our southern lands so little properly conducted experimental work has been carried out and so little data of value are available, even as a general guide let alone anything definitely applicable to particular parts, that the forester has to make the best, under each set of conditions, of such as he can gather direct.

Under such circumstances it is advisable, in the meantime, to restrict any extensive afforestation operations to the use of such species of which there is little doubt as to their absolute suitability, both as to satisfactory growth and for the production of timber, under suitable sylvicultural treatment and with the use of preservatives, that will reasonably answer requirements.

But systematic experiments should be carried on in each locality so that as soon as possible any modification of treatment and any inclusion of other species that are thereby indicated as advisable may be adopted as early as possible.

Much less loss and disappointment, if any at all, would result from limiting the number of species to those of which there is no doubt, than would occur if the number was extended to include uncertain ones.

Softwoods.

For softwood producing species for afforestation purposes in our southern lands we have undoubtedly—with few exceptions such as the Canary Island pine and possibly the Corsican pine—to look to those from America, and especially to the Pacific slopes.

All the most important and most rapid growing softwood species come from California and northward.

The western members of the family show a much greater proportionate increase in rate of growth in their new southern

homes than do any of the family from the Eastern States, or of those from Europe.

Very many of such as come under the usual designation of softwood have been tried in our southern lands, in private, communal, and State plantations.

The earlier private planting, if exceeding actual ornamental, was largely experimental, but much of the later private planting has extended to establishment of general utility plantations consisting of fairly reliable species.

Communal planting, which followed private, has also proceeded upon the lines of later private planting.

On the other hand State Service, except South African, planting, which should have been restricted strictly in the first instance to such species of which definite local information was available, and to the establishment of comprehensive experimental areas in various situations, failed to include the latter, and in important instances consisted of extensive planting of an unduly wide range of species, of very many of which there was no local knowledge. So wide was this range that many species were planted in great numbers of which there was not the least hope of any beneficial results under any conditions.

Great numbers belonging to other species were planted where much better class timber producers would have thriven. They were also planted in remote places, and generally were subject to wrong sylvicultural treatment.

Unfortunately these extremely costly, because so extensive, rash ventures have served no useful purpose, for nothing, or practically nothing, has been added to what was previously known.

Some indication has already been given in an extract in the chapter on "Need for Data," in this connection, of what was done in New Zealand, and reference was made to a number of different species, and there is no need to refer to them again, except to mention that these ill-judged earlier operations are a trying legacy to present State Service officers.

In the case of South Africa considerable experimental work has been carried out.

As the suitability or otherwise of many species varies very greatly in each of our southern lands and in each class of situation, only such species as have a fairly wide range of suitability are dealt with here.

As mentioned elsewhere, the timber of some species of Eucalypts is, whilst comparatively young, entirely suitable for most of the purposes to which the timber of what are generally known as softwoods is put, and therefore as some species, such as Saligna, give an acreage yield in say 16 years that exceeds that of any of the pines, it is highly advisable that wherever the situation is suitable to their growth, they should be grown, at least, in part, so that pines may not have to be solely depended upon for softwood supplies.

Hardwoods.

Whilst in the Northern Hemisphere there is a wide range of hardwoods which are included as recognised timber producers, such as the many species of Oak, Larch, Birch, Beech, Ash, Maple, Hickory, Elm, Alder, Lime, and Walnut, in our southern lands the species generally suitable for afforestation purposes are confined to quite a few genera, though including many species, of which those of the Eucalypts form the greater number and far the most important.

Unlike the species of softwoods suitable for afforestation in our southern lands, which are all exotics from the Northern Hemisphere, and of which many species have already failed to resist disease, therefore they must in each of our southern lands be judged to be only on their trial, most of the hardwoods are Australian, and the Eucalypts seem to be well suited to the conditions prevailing in New Zealand and parts of South Africa.

Whether softwoods or hardwoods, the first aim must be towards conditions that will as far as possible tend to resist disease, and next, that will ensure the most rapid growth of the qualities of timbers that are required.

If case-timber, then first clean boles followed by the most rapid expansion of diameter. If high grade building and general purpose timber, then again, first long clean boles, followed by steady somewhat retarded diameter expansion. If timber with hardness, denseness, and strength is required, then the choice should be of species that will naturally produce such, but assisted by dense planting, sufficient density being maintained until practically the full size required and maturity is reached.

Chapter XXXIX.

PINUS INSIGNIS.

(syn. *Pinus radiata*).

The name Pinus insignis is used here because it is so much more widely known under that name than under the correct name—P. radiata.

Seeing that the consumption of softwood is proportionately so enormously greater than that of hardwood, and that a famine in softwoods is predicted as imminent, therefore what is most important in connection with afforestation in our southern lands is a species of tree that will thrive well under the widest range of conditions in these lands, and which will produce a large bulk of serviceable softwood with great rapidity.

It is the conviction of the writer that if only it can be kept free from loss of vigour in its new homes the Insignis is destined to become a tree of very great value, and quite the most valuable tree in each of our southern lands.

The South African Forest Department issued in 1925 the most interesting and informative matter yet published on the Pinus insignis—Bulletin No. 15, "Pinus Insignis in South Africa," by N. L. King, District Forest Officer, Cape Province, and the liberty is here taken of quoting figures there given as to yields, and also a part of the Introduction as to its natural distribution, as it covers very fully the essentials as to its origin necessary to be borne in mind in connection with the use of the species for afforestation purposes in our southern lands.

"Natural Distribution."

"**Locality.**—The natural distribution of Pinus insignis is very restricted. It is found only at three points of the Californian coast, south of San Francisco, and on the islands of San Guadalupe, Santa Rosa, and Santa Cruz. The largest natural forest is that of Del Monte, on the Monterey Peninsula. This forest covers an area of between 5,000 and 6,000 acres. The San Lucia mountains are the natural habitat on the mainland, and it is of interest to note that the tree is found only at the northern and southern extremities of the mountain range, in spite of the fact that apparently favourable habitats exist

in the intervening region. It has been suggested that geomorphic movements are the casual factors of this peculiar and restricted distribution.

The northern and southern occurrences lie approximately between the thirty-fifth and thirty-seventh parallels of N. latitude.

Climatic Conditions.—The climate of Monterey Peninsula is characterized by a winter rainfall, daily fogs during the summer, and an extremely mild and equable temperature. Following are particulars:—

"The average rainfall of the Monterey Peninsula, based on records for twenty-five years, is 18·13 inches. The maximum and minimum annual rainfall for which records are available are respectively 28·66 and 10·10 inches. This rainfall occurs in winter and early spring. The summer fogs, however, which drift in daily from the ocean, play an important part in the growth and reproduction of the tree, inasmuch as they prevent any excessive drought, and compensate very considerably for the rather low winter rainfall. The mean annual temperature is 56·4° F. The highest temperature is 80° F., and the lowest 30° F. August is the hottest month of the year, with an average maximum temperature of 61·9° F., and January the coldest, with an average minimum of 50·2° F. The highest point on the Peninsula is 800 feet above sea-level, and from here the ground slopes gradually down to the ocean."

Soils.—These vary from an almost pure sand (found in dunes along the beach) to a fine sandy loam, which lies in a belt from one-half to a mile wide along the slopes behind the sand dunes. On the upper slopes the soils are for the most part gravelly and sandy clays.

"**Growth.**—In the Del Monte Forest the tallest tree of which a record is available was 115 feet high and 42 inches in diameter, while the tree having the greatest volume was 82 feet high and 59 inches in diameter. Elsewhere the trees occur mostly in groves, and are stunted in character, although trees having a height of 70 feet are occasionally encountered."

The Pinus insignis is, in its native country, by no means an important tree, and considering the extraordinarily rapid growth and the size it attains to, and the extreme readiness with which it is reproduced, and the great variation of climatic and soil conditions it readily adapts itself to in new homes, it is a matter for wonderment and serious consideration that in

its natural habitat it is restricted to such very narrow limits, and that though the climatic and soil conditions there are, by comparison with those in many places where it thrives well in new homes, by no means unfavourable it attains such comparatively small dimensions.

These circumstances, are distinctly suggestive that the species is approaching the end of its life in its natural habitat. If this is so the question arises as to whether the extraordinarily renewed vigour it displays in its new homes will prove lasting, and whether very especial precautions should not be taken in sylvicultural treatment to guard against decline.

The Pinus insignis in its new homes seems to adapt itself to an extraordinarily wide range of conditions, both climatic and soil.

Temperature.—Whilst it is sensitive to a high degree of heat associated with dryness, it will stand much heat if there is sufficient moisture. The highest temperature of its natural habitat is given as 80° F., and the lowest as 30° F., the mean annual as 56·4° F., but it will thrive well where there is a much greater range, and also where the mean is considerably lower and also where it is higher.

Rainfall.—Again as to rainfall, the Insignis thrives well under widely different degrees of rainfall. Under certain circumstances it will do with as low as 20 inches and as high as and over 150 inches. But dry winters with rainfall in summer are distinctly unfavourable. A low rainfall, but in the winter, with as indicated earlier in the quoted account of conditions in its natural habitat, moisture in the summer will answer, but undoubtedly a fairly high rainfall—most in the winter but a fair proportion in the summer is the most favourable. The optimum has been placed at 45 inches, but there is reason to believe that it is higher, even 60 to 65 inches.

Soil.—Insignis, just as in the case of almost all other trees, will not thrive satisfactorily and attain full development either in over-wet or over-shallow soils; beyond that it thrives in a great variety of soils, but not well in extremely poor ones of certain classes. Practically any deep friable soils are the best. It will thrive in almost pure sand so long as there is sufficient moisture, and excellently so in deep sandy loams, deep friable loamy clays, any deep porous clays, but not so well in impervious clays. Pumiceous soil, so long as the subsoil is porous, is quite satisfactory.

Degree of fertility is not of importance, nor does the condition of the soil, such as to whether it has been cultivated or not, matter.

Size.—It is noticeable that the largest tree recorded in its natural habitat measured 115 feet in height, with a diameter of 42 inches. In South Africa heights of over 140 feet are attained. Somewhat the same in Australia and in New Zealand 160 feet and over, and in some instances a diameter up to and over 5 feet. Single trees containing from 7,000 to 8,000 sup. feet of timber are met with.

Rate of Growth.—Pinus insignis is certainly the most rapid growing pine in the world and it may be considered the most rapid tree, for although for a period of growth some of the Eucalypts outgrow it in height, in timber content the Insignis comes out ahead in rate of production. During the first few years the rate is by comparison with later growth slower, and then increases, making the most rapid progress from about the twelfth to the twentieth years, after which it gradually slows down, reaching its full height between the thirtieth and fortieth years, but usually much earlier. Diameter growth continues, under favourable climatic and soil conditions, exceptionally until about the fiftieth year. At times as much as 8 feet vertical growth is made in one year, but for a number of years during the vigorous growing period 4 to 5 feet is a fair average.

Of course all rates of growth are dependent upon the situation and the sylvicultural treatment, and the length of the growing period is especially dependent upon the depth and degree of porosity of the soil. In certain soils growth, especially vertical growth, ceases early.

When growing in single row or independently as much as from 2 to 3 inches diameter growth per annum is added for a time, but of course timber from such would be low grade.

Yields.—Yields of over 100,000 sup. ft. per acre are indicated for South Africa, somewhat over that for Australia and definitely over 200,000 sup. ft. per acre is recorded for New Zealand. It seems probable that in favourable situation and with proper sylvicultural treatment a yield of 300,000 sup. ft. per acre and over (including all intermediate cuttings) could be attained in a rotation period of 40 years and upwards.

While yields will vary greatly according to the "situation" they will vary, taking the whole rotation period, much more

Insignis in Pukekura Park, New Plymouth. These trees are about fifty years old, 150 feet in height, and nearly five feet in diameter.

according to the sylvicultural treatment, and therefore at the best figures given are only approximate, and of most value for purposes of comparison.

It is interesting to note here that figures given by the late Sir David Hutchens as to annual increments in South Africa show Insignis and Eucalyptus saligna as practically equal, making considerably over 500 cub. feet each. Unfortunately there is no information available to indicate for how many years a similar yield would continue in either case, or how soon one species would forge ahead of the other.

Timber.—The timber of the Insignis has been given a bad name, first by the conversion into timber of shelter lines and belts, and next through the improper sylvicultural treatment. New Zealand and Australia are far the worst examples. South Africa, on the other hand, has tended towards better methods, at least in part. In the first two named countries the plantations of Insignis have been mostly "pure," in New Zealand almost entirely so. The spacing in some of the earlier plantings in New Zealand was reasonably close, but there was an almost entire neglect to thin. Later plantings in New Zealand, and most planting in Australia, was far too openly spaced, with the result that most of the timber milled from such will be fit for little else than box timber, and then the waste will be great. The plate shown in Chapter XI. illustrates such very clearly.

There were two reasons for this unwise over wide spacing, viz.—(1) planting in remote locations where thinning costs would be an unbearable charge on the forest, and (2) the very greatly mistaken idea (but very commonly held even in State Forest Services) that rapid growth obviated the need for close planting, under the misconception that the more rapid closing in of the spaces would kill the side branches quickly, overlooking what ought to have been quite obvious to anyone, the fact that rapid growth *meant rapid growth of the side branches* so that they would be so large and strong that when later killed, *but not eliminated*, they would remain as dead branches to the great detriment of the timber.

The timber of Pinus insignis properly grown is exceedingly valuable, and has a wide range of utility. Under no circumstances is it either a very strong or very durable timber, but these two qualities are not common to very many timbers, and seldom go together in the case of softwoods, although several of such are very durable.

The quality of Insignis timber varies greatly according to the way it has been grown and its age. That of young trees—say up to 15 years—has little strength, and it is not at all durable or suitable for any such purpose as building timber; on the other hand it is excellent as a case timber, for pulping, and such like. As a case timber, if well grown, it is quite strong enough—durability is not required—it is light in weight, 20 to 30 or even up to 40 lb. per c. f., clean, free of resin, and untainted by smell or otherwise if seasoned, and it is above all an excellent nail-holding timber, nails may be driven within a quarter of an inch of the edge, and is of a somewhat matted texture, and so has no tendency to split. It is in fact one of the very best case timbers.

The timber of properly grown trees 25 years old and upwards preferably 35 to 45 years old—is, though by no means of the highest class, excellent as a general purpose timber, building, joinery, furniture, and is especially good for forms for concrete work, as it is not inclined to warp.

Matured timber has proved to be, without treatment, distinctly durable as a building timber, houses of over 30 years of age built of it were examined and found to be quite sound. Its disrepute was entirely due to the use of timber from trees quite unfit for milling, which was soft, greatly varying in density, full of loose knots and other blemishes, and weak; on the other hand, timber properly grown is long straight-grained, of even density, quite free from loose knots, of considerable durability, and fairly strong.

It is important that Insignis should be milled without delay after felling because of the "blueing" (discoloration by fungus) and for the same reason the sawn material should never be piled in close contact, but should be so stacked as to give ample ventilation and preferably under cover.

Strength.—Insignis timber is generally supposed to be over weak. Whilst it does not hold a place among timbers which are specially valued for their strength, it certainly compares favourably with many softwoods, even amongst those used for structural purposes, and is distinctly stronger than some of those which rank as the highest class for their suitability for working, appearance, and durability, such as Redwood and Western Red Cedar. It is also superior in strength to much of the Baltic deal (*Pinus sylvestris*), much of the Oregon that is imported, though slightly less strong than good Oregon. It is also stronger than some Corsican, and very much stronger than Cluster pine (*Pinus pinaster*).

Some interesting tests were carried out by Professor R. W. Chapman, of Adelaide University, as to comparative strengths of Insignis, Pinaster, and Canary Island pine, but unfortunately the information in the hands of the writer does not include that, as to the number of annual rings to the inch or the age of the trees from which the timbers tested were taken. As practically all the planting in South Australia was "open" or over "open" such of the timbers tested as were taken from local grown trees would probably result in disadvantage to the faster growing species.

The following are the particulars of the tests given in the *Australian Forestry Journal*:—

"Several hundred tests of the timbers were made, and the outstanding feature of them all was the great strength of the Canary Island pine as compared with the others. Taking the average weight of all beam tests, a beam of this timber 12 inches by 12 inches and 12 feet long will carry a central load of about 42 tons before it breaks. An insignis beam of the same size will carry 24 tons, and a maritima 19 tons. Oregon beams of the same size will carry 26 tons."

It would appear from the above that the strength of the Oregon was taken from records, and that no test of it was made at the time. It is therefore probable that the strength of the Oregon given was that of a natural grown Oregon, probably hundreds of years old, and so could not fairly be compared with local "open" grown Insignis of probably 30 to 35 years of age. Such a comparison might be as unreliable as a guide to comparative strengths as that made by the New Zealand State Forest Service with New Zealand grown Redwood 21 years old grown in excessively "open" plantation, showing only 2 annual rings to the inch, with natural American grown Redwood showing 19·1 annual rings to the inch, and doubtless very many hundreds of years of age.

However the strength of Insignis timber shows in the Adelaide tests only two in twenty-six below that of Oregon and six above that of Pinaster.

It is 12% stronger than that of Pinus strobus, and has a greater resistance to splitting and shearing, and less easily compressed than that of Oregon.

The following are fuller particulars of the results of tests made:—

Beam tests, modulus of rupture in lbs. per square inch—Insignis 7,223, Oregon 7,322.

Modulus of elasticity in lbs. per square inch—Insignis 1,372,055, Oregon 1,817,438.

Shearing in lbs. per square inch, across the rings—Insignis 675, Oregon 481; parallel to the rings, Insignis 763, Oregon 407.

Compression in lbs. per square inch—along the grain, Insignis 4,916; Oregon 7,943; across the grain, Insignis 1,407, Oregon 1,244.

Had the tests been made with the timber of Insignis and Oregon of equal age and grown under the same sylvicultural condition there is no doubt that the results would have been even much more favourable to Insignis.

Durability.—Insignis timber, when that of matured and properly grown trees, is quite a reasonably durable timber for all ordinary purposes, but with some exceptions, it is not durable "between wind and water." It has a very distinct advantage over many other timbers, and that is that it is not attacked by the White pine borer.

Preserving.—In the case of Pinus insignis any lack of durability in its natural condition can easily be made good by treatment with preservatives. The late Sir David Hutchens, in his *Australian Forestry*, wrote as follows:—

"Insignis pine is one of the best timbers known to impregnate with an antiseptic."

Creosoted Insignis sleepers in South Australia were found to be quite good after six years, and were in a better condition than sleepers of any other timber.

Sylvicultural treatment.—For paper pulp the wood of Insignis is good when comparatively young, and for any other purpose that entails quite early clear cutting, the growing of Insignis "pure" may be considered advisable, but otherwise "pure" planting, except to a very limited extent, should be avoided.

Its very rapid growth prevents mixture, at simultaneous planting, with most other pines and many other trees, but several of the Eucalypts and some Wattles can safely be mixed with Insignis in the one planting to great advantage. The particular species of Eucalypt suitable for mixing in any situation can only safely be judged by their known rate of growth in the particular situation.

In situations where C. macrocarpa grows rapidly, a very satisfactory mixing of it with Insignis can be carried out by first planting the Macrocarpa and giving it some three to five years start, and then interplanting alternately with Insignis.

Insignis is a fair but not a full shade bearer, and can be used quite satisfactorily, with benefit to both and to the forest floor, for underplanting Eucalypts when the latter have attained considerable height growth, either in the original density of the stand or after thinning. Insignis can also be used for interplanting anywhere where the shade is not complete.

Mixtures of Insignis and Eucalypts have been grown successfully in South Africa, Australia, and New Zealand, and with Wattles added certainly anyway in the latter country.

"Over open" planting—say 8 x 8 and upwards—whether "pure" or "mixed" can in no case give satisfactory results. If the object is case timber it will be full of knots, costly to deal with, and with heavy waste. If for pulping, the excess of branches would add greatly to the cost of logging, and increase waste. If for building and general purposes it would be coarse, knotty, weak third class material.

The planting should always be close, followed by repeated thinnings. If "pure" planting, the density in the first instance should on no account be less than that obtained by spacing of 10 ft. x 5 ft. on the alternate system, equal to 871 plants per acre. If "mixed" as much as 2,000 trees per acre may be planted, about one quarter (500) being Insignis, which should by repeated thinning, be reduced to about 100 pines to remain for the final crop, or even half that number if the rotation period is to be long with the object of getting fully matured large sized timber.

The produce of trees that were in the first instance planted densely, and which were thinned with judgment throughout their growth, is a highly valuable timber, clean, fairly strong, light in weight, easily worked, dresses well, takes a good surface, and varnishes nicely, and has not its superior as a nailing timber.

Undoubtedly the Insignis is the most valuable tree for afforestation purposes in our southern lands, and in the writer's opinion is with the Redwood and some few species of Eucalypts destined as the most important in solving the world's timber problem—the coming famine.

But proper methods of growing must replace the reckless—it may be said senseless—wide spacing, pure planting which is now so general.

Chapter XL.

PINUS PINASTER.

(Syn. *P. maritima*).

Cluster Pine.

Pinus pinaster cannot be considered a valuable timber producer, and yet it has proved a tree of great value in some places.

As in the case of South-west of France, it is an excellent tree for reclaiming sand wastes and for growing in pure dry sands and in over-poor soils (though it does not like soils with much lime), and in situations too dry for Pinus insignis.

For these reasons it is highly thought of in many parts of both Australia and South Africa, but in New Zealand there are few situations where pines of greater value cannot be grown. It is distinctly of considerable value for underplanting in grown Eucalypt stands that have become too open and the forest floor is so suffering, in situations that are too poor and too sandy and dry for Insignis. It is a slight shade bearer, and therefore will stand any shade there would be under such conditions.

The Cluster pine will reach a height of 80 feet, but usually very much less, say 60 feet, with a diameter from 2 to $2\frac{1}{2}$ feet or more, but in some situations from 15 to 18 inches. As a rule the stem is somewhat irregular, and the branches spreading, crooked, and sparse.

The tree grown in France is somewhat different from those grown generally in New Zealand. The French type is a finer tree, and reaches a diameter of up to 4 feet.

The Pinaster's rate of growth is about half that of Insignis. It is less easy to transplant than the Insignis, but is a very free natural regenerator, and is inclined, in situations that suit it, to spread rapidly.

At one time, in New Zealand anyway, it was somewhat valued as a coastal shelter tree, but it has been quite replaced by Pinus muricata (Bishop's pine), Cupressus macrocarpa, and Insignis.

The timber is coarse, rather heavy, resinous, not strong, and whilst useful for some purposes such as round timbers for

props, has seldom profitable size for milling, and has little value as such. It is fair fuel.

Because of its spreading sparse branches and sparse foliage it answers in a shelter line as an excellent tree up and through which a dense hedge can grow. The writer has a complete dense wall fifty feet high so formed with Eleagnus as the hedge plant.

There is no warrant for growing Pinaster where Insignis will grow.

Chapter XLI.

PINUS CANARIENSIS.

Canary Island Pine.

The Canary Island pine is one of the most valuable of pines on account of its very great durability and great strength. The latter is a quality possessed by very few of the timbers which come under the general term of softwoods, though some of such are by no means softwoods.

The limitations of its suitability as a tree for afforestation are restrictions as to climatic and soil conditions, rate of growth, and difficulty of transplanting.

Climate.—The Canary Island pine requires a warm climate with the rainfall in the winter. It will not thrive where the rainfall is in the summer or even where there is much rain in the summer, though it may be much less than that in the winter. It will grow well with quite a low rainfall, even as low as 20 inches or less, and will stand very considerable drought, in fact it is one of quite the very best drought resisters, no doubt consequent on its having a very long tap root.

Soil.—It is really a hill or mountain pine, it will not grow in cold, wet, or sour soils, seems to prefer firm or stiff stony or gravelly soils, even shallow. In its natural home, Canary Island, it grows from sea level up the mountain slopes into the winter snow areas.

Size and Rate of Growth.—It reaches 130 feet and over in height, and 6 to 7 feet in diameter. Its rate of growth is from a half to two-thirds that of Insignis. Twenty year old trees

in Victoria reached 45 to 50 feet. The average growth of a plantation at Burndaleer, in South Australia, at 41 years of age is given as 62 feet height and 13½ inches diameter, and this with a rainfall of only 23 inches and at an elevation of 1,500 feet. At the Forest of Kinto, with a rainfall of 36 inches and at an elevation of 980 feet, the average growth of a block of 22 year old trees was 43 ft. in height and 9½ inches diameter.

Disease.—The late Sir David Hutchens and others have stated that the Canary Island pine shows no signs of any fungoid disease.

Value and General Suitability for Warmer Parts.—Undoubtedly this pine is a most valuable pine for warmer parts of our southern lands. It thrives well, and is most suitable where the rainfall is low or comparatively low, stands very considerable drought, grows on hard, stony, comparatively poor soils, is a considerable fire resister, and if burnt over even when only a few years old, will regrow from the stumps. It is a very strong, very durable, high class timber, and it is a very considerable shade bearer very excellent for underplanting grown Eucalypts in certain situations, and even underplanting or growing with, young slower growing high class Eucalypts.

Establishing and Regeneration.—The one distinct drawback in connection with Canary Island pine is the difficulty in connection with nursery treatment and transplanting. It makes a long tap root and little else, and although the seedlings may be dealt with in the nursery when quite small with apparent success, are later very apt to damp off, or otherwise fail, and are exceedingly difficult to transplant. Sowing in fairly large split tubes may better conditions, but sowing "*in situ*" is quite the best. It is a very free regenerator. The trees bear cones when quite young, but the seeds are not fertile from trees under 20 years old, the germination is about 25%. Seedlings will come up freely among the grown trees, and at some distance from them.

The tree is such an exceedingly valuable one for afforestation purposes in the hotter and drier parts of our southern lands that difficulties as to establishment should not deter considerable planting. It is doing excellently in parts of South Africa, in South and Western Australia, and in Victoria, and individual trees have grown well in parts of New Zealand—Nelson, Wellington, Wanganui, and north, but is only suitable for the drier parts.

It is one of the very few pines that sprout from the roots—others are Redwood and Pitch pine (*Pinus rigida*). This quality of sprouting freely from the roots even when quite young is a very valuable one; it is especially so in the case of fire. Young plantations of Canary pine have been burnt over and apparently destroyed, and yet completely recovered.

Of course the Canary Island pine requires a much longer rotation period than the Insignis. The timber of young trees is comparatively quite poor to that of matured trees, and for timber of the quality obtainable from young trees it would be much more profitable to plant a faster grower, and further it would be a great waste to sacrifice young Canary pines.

A rotation period of 50 years and upwards should be considered, therefore under planting of valuable gums, such as some of the Ironbarks with Canary pines seems advisable.

Wherever the Canary pine will thrive it should, when strength, durability, and high quality is required, hold first place.

Whilst Insignis stands pre-eminent as a producer of a good general purpose softwood for which there is a growing unlimited demand, and the Redwood as a high-class durable softwood, the Canary pine is the only one that can be looked to for a really strong finer type softwood—so-called.

True it is hard to establish and very sensitive as to situation, but as a small proportion of such wood is required in all countries such situations as are favourable for its growth in each of our southern lands should be ascertained, and a reasonable number planted.

Chapter XLII.

PINUS TORREYANA.

As in the case of Pinus insignis, the Pinus Torreyana shows a most remarkable renewal of vigour and increased development in its new southern homes over that in its natural habitat, which is Southern California.

There it would appear to be a dying out species, only now existing within very restricted limits, and is so poor a tree that it holds no place whatever as a timber producer, being

quite stunted, 30 to 50 feet, the latter at most, in height, and ill shaped.

In its new southern homes it has developed into a very fine large well-shaped tree, and has proved a rapid grower in certain situations, taking next place to the Insignis.

It has not been extensively planted anywhere in the south, and there is very little yet recorded as to its climatic and soil requirement, but judging from the conditions where it has shown excellent growth, it is hardy, standing exposure and considerable severities, a fair to a heavy rainfall, and likes fairly porous and deep soil.

The Torreyana has reached a height of 100 feet and a diameter of 42 inches in New Zealand. There are, or at least were, some very fine trees at the Hutt, also in Wellington and Christchurch, and elsewhere. In New Plymouth there are trees of about 80 feet in height and 42 inches in diameter. At Rotorua there are younger trees.

Practically no information is available as to the quality of the timber of the Torreyana, but from appearance it would seem to be of fair quality.

The tree as it grows in New Zealand is a fine looking tree, rather sparsely branched, and not affording much shade it would seem likely that it would be much better to grow it in mixture or then to underplant later. Judging by the dimensions it reaches, the rate of its growth, and its hardiness it is probable that it will prove quite a good pine to grow in at least some parts of our southern lands, but should it be proved that the timber has no special qualities and not high class it would be more profitable to grow Insignis.

Chapter XLIII.

PINUS MURICATA.

Bishop's Pine or Prickly Cone Pine.

The Muricata has no place as a timber producer, but it certainly has an important place in connection with afforestation, as it is a very hardy grower and good shelter tree, especially so in coastal areas and on sand dunes, and as a protector and reclaimer of the latter it is most valuable.

It being a hardy dense grower and a retainer of its lower branches right to the ground in dense green growth for a long period, it is most valuable for protective purposes on plantation margins, shelter belts, and lines.

It is on the whole hardier than the Pinaster, and it gives very much better shelter, but whilst the timber of the Pinaster has considerable value, that of the Muricata has very little, and therefore it should nowhere be used in preference to Insignis for other than protective purposes.

The form of the Muricata when grown naturally with plenty of room is somewhat pyramidal, and so the lower branches continue to grow and maintain dense cover to the ground, unlike those of species the spread of the higher branches of which is greater than that of the lower ones, which latter are as a consequence either killed right out or then become so sparse as to provide no shelter.

The Muricata will stand sufficient trimming to permit of its natural inclination to be intensified in the direction of maintaining a complete green surface from the ground upwards.

Planted as an outer row of a plantation, margin of a shelter belt, or of a farm woodlot, against Pinus insignis or any other tall growing tree the Muricata will naturally, to a great degree, and can be made with a little trimming, form such a complete dense inclined green face without a break to join in with the green tops of the inner taller growing trees of the plantation or shelter belt that it will form a margin wind and fireproof if kept clear of all dead material.

The Muricata is only a small tree, its usual size is about 40 feet in height and 12 inches diameter, though it will grow under exceptional circumstances to as much as 100 feet in height, and some trees to nearly 3 feet in diameter. Apart from the fact that its timber has no very valuable qualities its usual size is below that of useful milling timber, and its rate of growth is from a half to two-thirds that of Insignis.

As it grows well in South Australia, where, by the way, it has been grown in plantations to a considerable extent, though for what purpose is hard to say, it will stand considerable heat, low rainfall, and drought, but it seems to thrive best where there is a considerable rainfall and under cooler conditions. It is not sensitive as to soils, thriving well under many conditions, but probably not if extremely poor. It is growing satisfactorily in parts of South Africa and also in

Tasmania, where it attains large size. It thrives practically anywhere in New Zealand. There are marked variations in form which are noticeable in most plantations owing to the use of mixed seeds.

The rough-barked variety grows to greater dimensions, and is the more valuable tree compared with the smooth-barked one.

The timber of Muricata grown in some places shows a fairly good grain, and apparently is quite a fair timber, and is reckoned by some to be equal to, if not somewhat better than that of Insignis, but generally speaking it is not only an inferior timber but usually undersized for milling purposes, and a considerably slower grower than Insignis.

Chapter XLIV.

GUIDE TO SELECTION.

The desire in this work is to stress what seems most advantageous to beneficial afforestation in our southern lands, and equally to point out what seems disadvantageous, therefore all that appertains to proper selection of species is of importance.

There are very many species of trees which will grow, and may even grow well, and which produce timbers of value, and which may have a very distinct value in other countries or are largely used in their natural homes because they are available while others are not, but when it comes to selection for afforestation purposes in special countries the position is very different indeed. Where there are, say, two species that thrive equally well and produce timber of approximately equal qualities, but one is a faster grower than the other, or grows equally but attains greater dimensions or matures earlier, then such should be selected and the slower grower or smaller, or the one that takes longer to mature should be rejected altogether. Again, if the faster grower, or the larger growing one, or earlier maturing one produces timber which is less durable, then the deficiency should be made good by the use of preservatives. And even if the timber is otherwise of less quality but will answer the purpose or purposes fairly well, the disadvantages of the slower species may outweigh this.

Apply such tests to quite a number of species reputed to produce timbers of value, and which hold assured places in their natural homes or other lands, and which have been tried and found to grow well in various parts of our southern lands, and which on the strength of such have been in some cases planted in numbers, even in very great numbers, by State Forest Services, and are generally recommended, they should nevertheless be left out of any selection, with the exception that if by chance any of such may under especial conditions prove to outstrip their otherwise successful competitors.

So that advantage may be taken of these exceptions where they may occur is one of the chief reasons for systematic local experiments. The planting of such species extensively, with exceptions in cases of special conditions, cannot do other than result in economic loss, and it is in this direction, added to improper sylvicultural systems and treatment that State Forest Services have so greatly erred.

A few among such species which from general repute and without analysing sufficiently their comparative merits and demerits have been adopted and largely planted are the following:—

Austrian pine (*Pinus austriaca* or *nigra*), Corsican pine (*Pinus laricio*), Old-Field or Loblolly pine (*Pinus tæda*), Weymouth or White pine (*Pinus strobus*), Western Yellow pine (*Pinus ponderosa*), and Larch. The last three are entitled to more consideration than the others.

Chapter XLV.

PINUS LARICIO (CORSICAN PINE), AND PINUS AUSTRIACA (AUSTRIAN PINE).

The Corsican pine is one of those species of which there are good reasons for doubt as to the wisdom of planting in our southern lands under any but special circumstances. Whilst it has the reputation of being a very good forest tree, and holds a somewhat important place among such in Europe, it does not by any means follow that it should do so in our southern lands. The chief points—in fact, the only points—in its favour are, that it is hardy and the timber is durable when from matured trees.

The timber is by no means highly valuable, in fact it ranks in price with that of Baltic deal. It is light, soft, and though, when from matured trees, durable, it is not so from young trees. In England about 80 years is considered a fair rotation period, but in the management of forests in Corsica a very much longer period is considered necessary on account of the excess of sapwood, which is not at all durable, in trees so young as 80 or even much over 100 years. The proportion of heart wood in a tree much under 100 years would be under 20%.

The very long period required for the Corsican pine to mature, and the distinct inferiority of the timber of immature trees is a very serious bar against the use of Corsican pine for afforestation purpose. The quality of the timber procured from aged trees taken from the natural forest has gained, especially in Mediterranean countries, a high reputation for the timber that should on no account be applied to the timber of trees grown on a short rotation such as 80 years adopted in England, and there is yet no evidence that the timber of Corsican pine grown in our southern lands will be even of equal quality, though doubtless of greater bulk, under that period. As far as can be judged it will require a rotation period of certainly well over 50 years, probably 60 years, to produce an equivalent bulk. Its rate of height growth is about half that of Insignis, which latter, if properly grown, would yield in half the period very many times over the quantity of timber, quite equal in quality to that of Corsican age for age, and in any case the durability of Insignis can be very greatly increased by the use of preservatives, of which it is the best absorbent, whilst the Corsican is truly a poor one.

Further, in situations suitable to it, the Redwood will produce many times over the quantity of timber and of an infinitely superior quality. In some situations unsuitable for growing Redwood, Oregon will thrive in and greatly outstrips the Corsican, and will yield a far more valuable timber.

Maw gives the acreage yield of Corsican as something over 5,500 sq. feet in 80 years, and the value per ft. 7d., and that of Oregon as 21,190 sq. ft. in 75 years, and the value per ft. as 9d. to 1s. 3d.

So far there is no information available as to yields or values in our southern lands, but the Oregon makes a much better proportionate growth in New Zealand and Australia than the Corsican.

As far as the Redwood is concerned there are no European yields to compare with, but in its native home the Redwood and Oregon stand right away ahead of everything else, and the growth of the Redwood in New Zealand, in many parts of which it finds most congenial conditions, is most remarkable.

The Corsican pine, being a very hardy tree, there are doubtless some parts in which it will thrive better than other species, and therefore there would be warrant for planting it in such, but millions of it have been planted in New Zealand, for instance, in situations where very much more rapid producers of good timber thrive excellently.

Pinus Austriaca or Nigra (Austrian or Black Pine).

This pine is closely allied to the Corsican, but is in practically every way far inferior to it. Except for high cold mountain positions it is not worth considering, and it should never be planted where any other pine, or in fact any tree that will produce timber, will thrive.

It has been planted in great numbers in New Zealand in situations where other pines of much greater value grow well. While there are some situations in the South Island where it thrives and where there was some warrant for planting it, there is no situation in the North Island where afforestation should be undertaken for the purposes of production of timber where the Austrian pine should be given a place.

Neither in Australia nor South Africa has the Austrian pine given any satisfaction.

Chapter XLVI.

PINUS PONDEROSA.

Western Yellow Pine.

Ponderosa is one of the great timber trees of the west, and has a very wide range, reaching from the Canadian border to lower California, and from the sea right over the Rockies. This is a wider range than any of the others, though the Oregon pine reaches much farther north.

The form growing eastward of the Rocky Mountains is an inferior tree known as var. *scopulorum*.

This form should have no place in afforestation, although it has been planted to some extent.

The Western Yellow Pine attains to the great size, in extreme, of 250 feet height and 12 feet diameter, and ordinarily up to 200 feet by 8 feet.

In its natural home it grows from sea level up to 6,000 or even 8,000 ft., and thrives in a great variety of soils, even in that on poor dry stony ridges, but whatever else it may be the soil must be well drained if the best results are to be attained.

The Ponderosa grows either in "pure" stand or mixed with the other great trees of the West, such as the Oregon, but it is a distinct light demander, especially so in early life.

Timber.—Owing to it being available in great quantities, in very large sizes, and as it is easily worked and suitable for a number of different purposes, it ranks as one of the most important timbers. This has led to it being held in higher estimation for afforestation purposes than is really warranted, for the timber is not one of high quality. It is exceedingly variable in quality. The best, though fine grained and hard, is brittle and not durable. Certainly far the greater quantity of timber cut from it would be from trees of several hundreds of years of age, and doubtless far superior to timber from young trees of say 60 years, and therefore again, in this case, the question arises as to the wisdom of planting a comparatively slow growing tree which produces no better if as good timber as some fast growing ones, except in places, where because of its hardiness, it may grow well where those others will not.

Ponderosa has been planted in large numbers in New Zealand, and thrives well in many parts, but its height growth is a long way behind that of Insignis, and Redwood, and others, and its annual increment of timber is very very far behind.

In some of the higher cooler parts of Victoria it has shown very fair growth not so far behind Insignis for instance, as it shows in New Zealand. In some other parts of Australia it has shown fair growth, but there would seem to be very distinct limits to its utility for afforestation purposes in Australia, and still less favourable prospects in South Africa.

Its rate of height growth in New Zealand ranges from 18 inches to a little over 2 feet per annum. One measurement recorded is that of upwards of 100 feet height by 2 feet 2 inches

diameter in 40 years, which is exceptional. Trees in the Rotorua district measure about 60 ft. height and 9 or 10 inches diameter at 26 years of age.

Its place in afforestation is distinctly where frosts are too severe for more rapid growing trees or those of better quality to grow. It is especially suitable for filling in frost beds unfit to grow the species of which surrounding plantations consist.

The Ponderosa, like the Redwood, is another great timber tree of the Western States that will not grow in the Eastern States.

Chapter XLVII.

PINUS STROBUS.

Weymouth Pine (The White Pine of the Eastern States).

The Weymouth pine does not attain to anything like the size of the great timber trees of the West, but still is a very fine tree, usually about 125 feet in height and 3 feet in diameter, but on occasions reaching as much as 150 feet height and 5 feet diameter. It was widely spread over the Eastern States right up to and over the Canadian border.

Owing to its general occurrence, size, and the general utility of its timber where lightness and softness were required, it became one of the important timber producing trees, and has been long grown in England and on the Continent. It was introduced into England by Lord Weymouth in 1705, hence the name "Weymouth," by which it is generally known at Home.

Of late years it has been attacked by disease and is now less planted.

Whilst it holds a place amongst the slow growing trees of the Northern Hemisphere it is doubtful whether there is any place for it in afforestation in our southern lands.

It has in some few places, especially in New Zealand, shown fair rate of height growth, but its annual increment of timber does not compare with that of many other trees that will produce better timber.

It is hardy and suitable for cool situations in some parts of Australia and for parts of New Zealand. It usually thrives better in higher elevations than in low country, and whilst it will grow in rather dry soils on hilly country, and also in

fairly dry sandy soil, it prefers fairly fertile, well drained, deep soil. It thrives in drained peaty or swamp soils.

One quality in its favour is that it stands a fair amount of shade, and is suitable for underplanting such as Larch, and perhaps for underplanting high quality slower growing Eucalypts it may have some value in situations suitable to it.

Timber.—The timber is white, soft, and very light in weight, only about 24 lb. to the cubic foot. It is not at all durable where exposed, and is 12% weaker than Pinus insignis timber.

Maw gives the rotation periods, yields, and values of Corsican, Weymouth, and Oregon as follows:—

Corsican—80 years, over 5,500 cubic feet yield, 7d. per c. ft.

Weymouth—80 years, over 6,300 cubic feet yield, 7½d. per c. ft.

Oregon—75 years, over 21,190 cubic feet yield, 9d. to 1s. 3d. per c. ft.

In good situations in New Zealand it has grown to a height of 50 feet and 10 inches in diameter in 25 years. In South Africa it has not proved a success.

Considering all things there does not appear to be any warrant for planting it in our southern lands for afforestation purpose, unless under some special circumstances.

The Weymouth pine is distinctly a better soil improver than many of the other pines.

Sylvicultural Treatment.—Whilst for the production of good grade timber dense planting is essential in the case of practically all species of trees, it may safely be said that in no case is it more essential than in that of the Weymouth pine.

The Weymouth pine stands a considerable amount of shade, and if planted at all openly will for long retain its side branches, which soon form heartwood, and when later these die their butts become impregnated with resin, and consequently will not decay or rot off, with the result that the timber is made almost valueless on account of the numerous loose knots. Further timber so grown is over weak and soft.

Quite close planting—not more open than the equivalent of 4 ft. x 4 ft. spacing—is imperative, and thinning operations should be carried out sparingly and on no account hastened. Such treatment will retard the growth, but is the only means by which timber of high grade, or in fact of any value can be assured. The consequent low annual increment even in favourable situations, places this species at a disadvantage compared with others that will grow in similar situations.

Chapter XLVIII.

PINUS HALEPENSIS.

P. Tæda and P. Patula.

Pinus Halepensis.—The Aleppo pine has been proved very prone to disease, and is otherwise of no importance for afforestation in New Zealand, notwithstanding that it has thriven fairly well in parts of Canterbury. In parts of Australia—West and South Australia—it grows much better, and is suitable for dry situations—it will stand as low a rainfall as 15 inches—where the soil is calcareous and therefore unsuited to the Pinaster. It also thrives fairly well in parts of South Africa, but in none of these countries can it be considered a valuable tree, and it is only worth planting in such special situations in which it may have been proved that it thrives better than do other more valuable trees.

Pinus Tæda (one of the pitch pines).—The Loblolly or Old-Field pine's home is the South-eastern and Southern States and it gets its name Old-field pine on account of the readiness with which it spreads into abandoned fields or waste places, and thus indicates that it would be a very good regenerator. It bears fertile seed prolifically when quite young—from 10 years of age and upwards.

It is counted in its native home a quick grower, and it usually, when growing densely, which it has to be to produce useful timber, is a distinctly slim pine 70 to 100 feet in height by 12 to 18 inches in diameter, but it will reach a greater height by 20 to 30 feet, and when grown in the open an extreme diameter of nearly 5 feet.

It has been tried in New Zealand, but with no marked success. So far it has been very little planted in Australia, and it is not likely to succeed in many parts sufficiently to warrant it being planted to any extent.

It has done best of all in some parts of South Africa, and may prove of some value there in certain situations. In hot coastal regions where there is sufficient moisture it has made excellent growth.

It is less light demanding than many of the pines, and so may be used in certain mixtures to advantage.

Timber.—The timber has no quality to recommend it. It carries much sap wood, is coarse, brittle, weak, and not durable,

At the best this pine can play a very unimportant part in afforestation in our southern lands, where many valuable trees grow with such rapidity.

Pinus Patula.—Sir David Hutchens, when conservator of Forests at Capetown, recommended the testing of the suitability of Mexican pines for growing in the Transvaal, and of those tried Pinus patula proves to be the best, and promises to be a tree of very considerable value for afforestation purposes there.

The first planting, only a few, took place in 1908, and later plantings were increased and extended so that plantations were established in Western, Midland, and Eastern Cape Provinces, Transkeian Territories, Natal, Transvaal, and Orange Free State.

The results in the Western and Midland Cape Provinces, and also in the Orange Free State, have not been encouraging, but in the other districts, at elevations from 4,000 to 6,000 feet, and where there is a summer rainfall, the Patula is proving a fast grower, 4 feet height growth per annum, and the average annual increment is estimated at over 500 cub. feet, but as the plantations on which the estimates are based run from only 6 to 14 years of age these figures cannot be taken as a guide to what the average increment over the whole rotation period may be.

However, the Patula promises to be an excellent tree for highlands where there is a summer rainfall, and where other more valuable pines will not thrive.

The Patula is a slender growing tree, reaching a height of 50 feet—occasionally up to 60 or 70 feet—with a diameter of 1 foot. It thrives best in deep soil in moist situations, where the rainfall is mostly in the summer and amounts to 30 inches and over. It should be planted densely. In South Africa the spacing has been from 3 ft. x 3 ft. to 6 ft. x 6 ft., but the latter is probably too wide, and a closer spacing, say 5 ft. x 5 ft., with early and repeated thinning, would be better.

Timber.—The timber of the Patula is exceedingly light in weight, about 24 or 25 lbs. per cub. ft., soft, brittle, and over weak, and only available in small sizes. It therefore has no place as a building timber, but might be used for some furnishing and for cases. It is a good nail holding timber. Probably its greatest value would be for pulping.

The Patula has not been planted in plantations either in Australia or New Zealand, and is not at all likely to be of any consideration in either country.

Chapter XLIX.

CUPRESSUS MACROCARPA.

Monterey Cypress.

The Macrocarpa is undoubtedly a tree of very great value. It is (1) very hardy, (2) a rapid grower, (3) excellent for shelter purposes, (4) a considerable shade bearer, one of the best trees for underplanting Eucalypts and others, and (5) one of the lightest timbers, strong and durable.

It is a somewhat strange coincidence that this very valuable tree for our southern lands, but especially for New Zealand, should have for its natural home mate the Insignis, which should be considered the most valuable species of all for these lands, and also that the Macrocarpa, like the Insignis, should be confined to very restricted limits in Southern California, and like it be apparently nearing the end of the life of the species in its natural home. And further, it is strange that the most valuable tree for afforestation for the production of high quality timber in our southern lands—the Redwood—is not a very distant neighbour, and is also confined to a restricted area, though not so restricted by any means as are the Insignis and Macrocarpa.

The Macrocarpa in its natural home attains comparatively small size, and is so unimportant that it is quite ignored. In our southern lands the Macrocarpa seems to have acquired an extraordinary new vitality over a greater range than any other species, unless possibly the Insignis. In New Zealand it seems to have met the optimum of favourable conditions, but it thrives well in parts of South Africa and of Australia, though in the latter country it is more frequently afflicted by a disease which it seems to have brought with it from its natural home. The same trouble attacks it, though to only a slight extent, in South Africa and Tasmania, and still less in New Zealand.

The natural form of the Macrocarpa when growing independently is that of a densely branched, wide spreading tree, the lower limbs close or almost close to the ground, giving a width of base almost equal to its height. Frequently instead of having one central stem with numerous lateral branches the tree consists of many stems with masses of lateral branches outwards at the base and ascending higher up.

Hardiness.—The Macrocarpa is an extremely hardy tree, and flourishes under a wide range of climatic conditions. It withstands salt sea winds almost better than any other conifer. One variety of it is especially hardy under such conditions. It thrives in almost any situation, so long as the soil is not too poor or too wet, from the sea coast to the interior, from the low country to very considerable elevations. It withstands quite a cold climate, and will stand considerable heat. In fact it will stand practically any conditions, except the greatest extremes, met with in our southern lands so long as they are not over dry and that there is a fair rainfall mostly in the winter.

Soil.—The Macrocarpa thrives far the best in good deep porous soils with a fair amount of moisture, but it will grow, and grow quite satisfactorily, in less good, and even in poor soils, so long as they are not too hard, or too shallow or dry. It will grow well in sandy soil, and fairly well even in almost pure sand, provided it is not over dry, and there is plenty of atmospheric moisture.

Shelter purposes.—Wherever it will do well the Macrocarpa is an ideal tree for wind-break purposes. It can be grown as a dense hedge of almost any size provided it is trimmed closely and frequently from quite an early stage, and provided the trimming is done so that the branches are not cut back into the hardwood and the hedge is allowed to gradually expand.

For a high and extensive break-wind it can be either grown alone in a single row or used as an outer row on the windward side of a taller growing and less hardy species, such as Insignis.

For plantation or forest margins, whether as a complete outer row only or as a margin partly out and partly within the plantation, it is quite the best where the conditions suit it and a fairly rapid growth is desired. Its natural tendency is to retain its side branches right down to the ground, but a

more complete density can be ensured by a slight degree of trimming, giving the outer face a distinct inclination inwards at the top.

A forest margin so formed will absolutely prevent the entrance of any wind, and will present a complete dense green face to any fire from the outside.

Underplanting.—The Macrocarpa is a very considerable shade bearer, and is an excellent tree for purposes of underplanting wherever the conditions naturally favour its growth, and where the species it is used to underplant do not render the soil conditions too dry. For underplanting Eucalypts, for instance, the Macrocarpa is excellent, and nowhere does it thrive so well and make such satisfactory timber growth as amongst, or underplanted, in the New Zealand native bush, so long as the top light is not too much obscured.

The Macrocarpa is satisfactory in many mixtures, but the suitable composition of mixtures is so dependent upon the effect of the situation on the relative rates of growth that, in each case, local knowledge is necessary.

For instance, mixing of Insignis and Macrocarpa, considering their general comparative rates of growth, would seem to offer very little promise of success, and yet the writer is acquainted with the whole circumstance of an instance of Insignis and Macrocarpa being grown together and attaining over 40 years of age with satisfactory results to the growth of both species from a timber producing point of view.

As has been stated, Macrocarpa is excellent both for underplanting in New Zealand native forests and in Eucalypt plantations, or natural forest, but the writer is not aware whether it has been tried in South African natural forests. It seems probable that in some of the rather open forests in parts of South Africa it could be used, where it thrives well, to great advantage in reinforcing to a beneficial density the natural forest there.

Growth.—The Macrocarpa, in favourable situations, is a rapid growing tree. It will make from one-half to three-quarters the rate of height growth of the Insignis, according to the situation. As an independent tree or in shelter belts its full height will be from 40 to 50 or 60 feet. The diameter varies greatly from about 18 inches to 6 or 7 feet, but such as have large diameters are generally, not far up, divided into many stems, or then are extensively heavily branched trees.

Grown under proper forest conditions the tree will reach a height of over 100 feet, with a diameter of about 30 to 36 inches b. h., but the taper is very considerable.

Yield.—The Macrocarpa has been so much used for shelter purposes, and its timber for fencing and fuel, and so little as a milling timber, that there is no definite information as to yield, but judging from its rate of growth and the size it attains in what would be approximately its rotation period, viz., 40 to 45 years, it would probably take third place—that is Insignis, Redwood, and Macrocarpa—or possibly fourth place, Oregon taking third place, in yield of exotic softwoods in New Zealand anyway.

Timber.—The timber of the Macrocarpa is of high quality and very valuable. It has a combination of qualities that very rarely go together. It is exceedingly light in weight, fairly hard, close-grained, very strong and durable even "between wind and water," and it is easy to work. Excellent for poles, fence posts, and good fuel, and generally a good timber for all purposes where lightness combined with strength and durability is required.

Further, unlike many other timbers, its qualities are little, if at all, affected by the way it is grown. It carries practically no inferior sap-wood, and develops its qualities early in life.

Sylvicultural treatment.—The young plants require care in transplanting. They—say 2 year olds, or even 3 year olds, for underplanting—should be well wrenched in ample time before lifting, kept moist, and carefully protected from wind or sun whilst being handled, transported, and planted, and especial care should be taken to see that the plants are thoroughly firmed in the ground. Moving should, as far as possible, be carried out during moist conditions.

If the production of straight clean timber is aimed at, dense planting is essential, whether planted "pure" or in "mixture." A spacing as close as 6 ft. x 3 ft. under the "double spacing" or triangular system, equal to 2,420 trees per acre, may be followed in a suitable mixture. Certainly in any case the spacing should not be greater than 8 ft. x 4 ft., equal to 1,360 trees per acre. The composition of the mixture, or the species being underplanted necessarily with the degree of suitability of the situation, has a great bearing upon the decision as to the spacing.

Mixtures.—Macrocarpa may be mixed with many species, but the composition of the mixture is subject to the relative rates of growth in any particular situation.

Among many species Macrocarpa may be mixed with such as Insignis, Redwood, Oregon, Sitka Spruce, and, under special circumstance, Thuya plicata (Western Red Cedar), also with Eucalypts, and used for underplanting some Eucalypts, some Wattles, New Zealand native bush, Pinaster, Canary Island Pines, but the last two only where they may be growing under comparatively moist conditions.

Macrocarpa One of the Most Valuable Trees.—Whilst the timber of the Insignis, the Macrocarpa's close neighbour in its natural home, came into most undeserved ill repute because of the improper way that it has been grown in New Zealand and Australia, that of the Macrocarpa has, for some extraordinary oversight, remained practically unrecognised. The fact that the Macrocarpa is so hardy, that it is a fast grower, that it thrives so well over such a wide range of situations and conditions in all our southern lands so long as the soil is not too poor or too hard or shallow, and so long as there is sufficient moisture, added to the very high quality of the timber, make it one of quite the most valuable species for afforestation in our southern lands.

What can be the use of attempting to grow the slow-growing Spruces, with their attendant great disease risk, or the much slower-growing Corsican, except in special situations where its hardiness and less demand for moisture may afford special reasons, or the slow Ponderosa, and many others, when such a tree as the Macrocarpa, with its rapid growth and far superior timber, can be so generally grown?

Disease.—The Macrocarpa has one fault, but it is apparently a slight one. It carried with it to each country where it was introduced a disease, the nature of which is not, the writer believes, so far understood.

It attacks individual plants or trees, or a few together, at any stage of their growth from plants in the nursery to grown trees. In grown trees it usually begins in the lower branches and ascends until the tree succumbs. Whilst in situations uncongenial to the Macrocarpa this disease may be considered troublesome, there would seem to be little reason for concern where the conditions are favourable to rapid vigorous growth, for the attacks of the trouble seem not to have progressed in the least on what they were 50 or 60 years ago.

Chapter L.

CUPRESSUS LAWSONIANA (Lawson's Cypress or Port Orford Cypress) AND CUPRESSUS LUSITANICA.

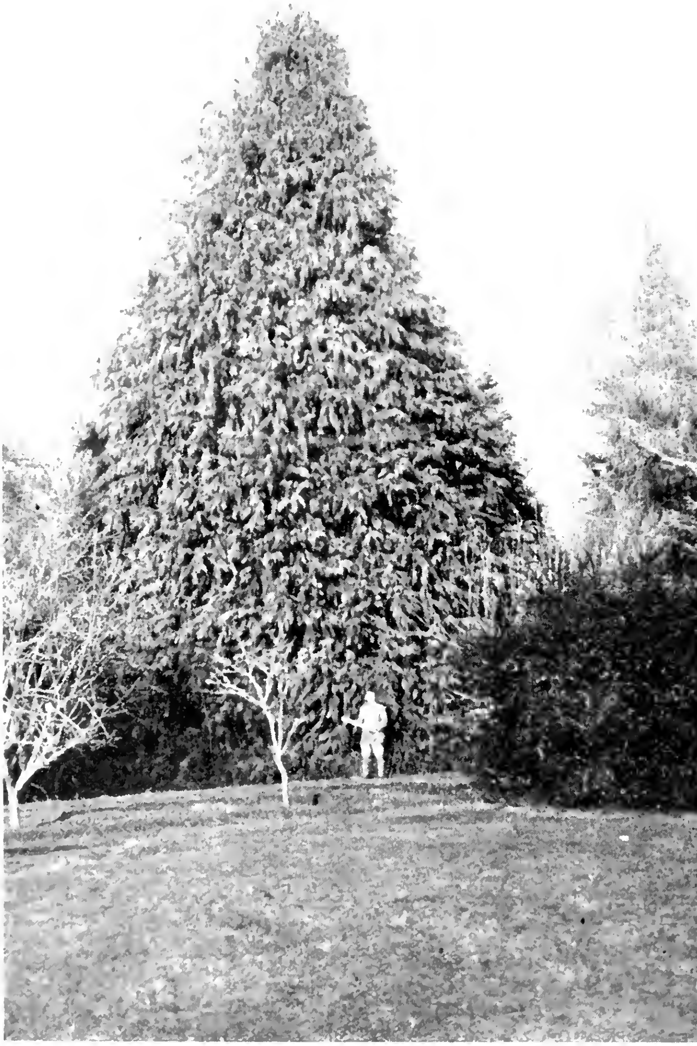
The Lawsoniana is a native of Northern California and Oregon. It is not considered as a timber-producing tree in its native country. Its value in our southern lands, to which in many places it takes very kindly, is that of shelter and ornamental purposes. Although it has recently been advocated in New Zealand as suitable for afforestation for timber production purposes, there appears little if any warrant for considering it worthy of a place in comparison with others that grow so much more rapidly. The timber is light, soft and durable, but its rate of growth is distinctly slow, especially so in earlier years. So far as any records that are available show, the annual increment is a very long way below that of other species which produce timber of as high or higher quality suitable for similar purposes. In New Zealand it makes its best growth inland and in the higher country.

As a shelter tree for close planting on margins the Lawsoniana is excellent, though distinctly slow growing at first and throughout a slower grower than the Macrocarpa, its natural form of growth is such as to give dense heavy green shelter right from the ground to the top.

Though it is slower growing than the Macrocarpa, and therefore would be unduly behind in growth that of the species of which the plantation consists unless they were of very slow growth, it has a distinct advantage over the Macrocarpa in that, whilst being of dense growth, it is much less spreading, and so takes less room and has less dead material inside the green.

It will not stand the salt sea winds like the Macrocarpa, and so is not suitable for coastal planting, though distinctly so for inland situations.

Though its usual form of growth is that of a central stemmed tree with lateral branches right to the ground, it very frequently, whilst retaining the outward pyramidal form, consists of several straight vertical stems. Such stems reach in time suitable dimensions for telephone or telegraph poles, but its slowness makes it distinctly unprofitable to grow for such purposes.



Lawsonia (*Cupressus Lawsoniana*) 40 to 45 years old, 50 feet high. Diameter of foliage at base, 30 feet.

But as a shelter tree and fire resister, especially so as an outer line of plantation margins, it is unsurpassed where its slower growth is not a bar.

Cupressus Lusitanica.

Though Cupressus Lusitanica has not shown any promise worth considering in either New Zealand or Australia, it has distinctly done so in Southern Rhodesia. In inland and elevated situations there it has made very rapid growth, and may prove to be a valuable producer of softwood in such situations.

Chapter LI.

SEQUOIA SEMPERVIRENS (Redwood).

The Redwood is certainly one of the most interesting and one of the finest, if not the finest, of trees in the world.

It is interesting because of its magnificence, its very restricted range, which is confined to a very narrow belt from ten to thirty miles in width, and in length about 300 miles, reaching from just inside the Oregon border to a little south of San Francisco, and because it is a survival of an ancient type at one time common in other parts of the world. The Sequoias are a link between the firs and cypresses, allied to the Taxads. The Redwood was named Taxodium sempervirens by Endlicher in 1847.

That the Redwood is one of the finest, if not the finest, of trees in the world is undoubted, but it is impossible to say definitely whether it is absolutely the finest, as there is some uncertainty about the exact measurements of the various competitors as to first place as greatest trees in the world. Height alone, or height with recorded diameter, cannot be taken as settling the point, as so much depends upon the proportionate taper and where the diameter measurements have been made, but the first five places as giant trees appear to belong to the following:—Redwood, New Zealand Kauri, Australian Eucalyptus regnans, Californian Big Tree (*Sequoia gigantea*), and Oregon. Whilst various measurements of big trees have been given from time to time many of such have on

Redwood (*Sequoia sempervirens*).

fuller investigation been discounted, but the following are measurements which appear to be reliable:—

Redwood.—An average size given to the Redwood by one authority is 225 feet height by 8 feet diameter. An extreme height of 346 and a diameter of 28 feet at the buttressed base. A definite measurement in one case of 308 feet high by 20 feet over bark diameter, and a timber content of 361,366 board feet. Such measurements appear to exceed that of any known tree.

Kauri (New Zealand).—A height of 75 feet to the first branch and a diameter of 22 feet with a timber content of 195,000 board feet is recorded, also in another case a timber measurement of some 230,000 board feet. Though no great heights compared with those of the Sequoias and Eucalypts are recorded for the Kauri, it is unique in its almost entire lack of taper, whilst excessive taper is the conspicuous feature of the Sequoias.

Eucalyptus regnans.—Whilst much greater measurements have been claimed for this species, nothing over 326 feet in height has been absolutely substantiated, and an extreme diameter of about 20 feet, but the writer is unable to ascertain any particulars as to timber content.

Big Tree (*Sequoia gigantea*).—This tree reaches a height of 350 feet and over, and extreme diameter of over 30 feet. One specimen measured was 325 feet tall, 35·7 feet diameter 4 feet above ground and 10 feet diameter 200 feet up. This diameter measurement of over 35 feet taken only 4 feet above ground gives no indication of what the diameter of the real trunk clear of the swelled buttressed base was, but the decrease to only 10 feet diameter 200 feet up indicates that the Big Tree is not entitled to better than third place on a basis of timber content.

Oregon (*Pseudotsuga taxifolia*).—The average size of the Oregon or Douglas fir is about 200 feet height by 4 feet diameter, but individual trees of 300 feet height, and others up to 12 feet diameter are recorded, also a timber content of 125,000 board feet for a single tree.

The stands of Redwood are almost unmixed with other species, and some are perhaps the densest timber stands in the world. It is recorded that as much as 1,500,000 b. ft. has been the yield of a single acre.

The Redwood not only lives to a great age, but it is recorded that one was still growing when 4,500 years old.

Whilst the Insignis, owing to its extremely rapid growth, early maturity, hardiness, and especially, in conjunction with these, the very wide range of climatic and soil conditions under which it will thrive, entitles it to first place among all trees for afforestation purposes in our southern lands, the Redwood, on account of its rapid growth and the exceedingly valuable timber it produces, certainly comes second for situations that suit it. If it was more hardy and adaptable to nearly as wide a range of climatic and soil conditions as the Insignis is, it would rank first, and far beyond every other tree for supply of softwood.

Climatic and soil requirements.—As indicated by its natural habitat, which comprises the hill sides and valleys up to an elevation little over 2,000 ft. of the coastal ranges of Northern California, the Redwood requires a fairly high rainfall and fairly moist atmospheric conditions. It will stand a fair amount of cold and heat, but not extreme conditions of either. It is sensitive to high or drying winds, and to do well requires sheltered conditions. The leader is apt to be broken if exposed to high winds.

The soil requires to be deep, fairly fertile and moist, but well drained. The better the soil—the more fertile, deeper, and more porous, but fairly moist—the more will the Redwood thrive; but the Redwood will grow in soil possessing no great fertility provided the other soil and the climatic conditions are favourable.

Rate of growth.—Under the favourable conditions indicated as in many parts of New Zealand, the rate of growth of the Redwood is extremely rapid, and a long way ahead of any other softwood except Insignis, and even greater than the Insignis in annual increment after about 25 years.

Very open grown trees in several places in New Zealand have made as much as 80 feet height growth and 3 ft. diameter in from 34 to 36 years. In the Rotorua district fairly closely "pure" planting it has reached about 60 feet height and from 7 to 18 inches diameter in 27 years.

In judging the comparative rates of growth by the increased diameter, it has to be remembered that the Redwood has a greater taper, and this is more marked in the case of trees grown separately or over widely spaced, but taking trees of Redwood and Insignis so spaced it has been observed by the writer that whilst during the earlier years the Redwood is well behind the Insignis in diameter at 4 feet from the

ground and therefore, due to greater taper, much behind in timber content, it will catch up in rate of diameter growth somewhere about the twentieth year, and from that on will outstrip that of the Insignis. If both are say 25 inches diameter in the twenty-fifth year, the annual increase of the Insignis will steadily decrease, whilst that of the Redwood will keep on increasing, and whilst the Insignis will have stopped growing at say the forty-fifth year, the Redwood will be adding annual rings of over half an inch in thickness or over an inch increased diameter. This quality of continued increasing growth is one of the chief factors that makes the Redwood such an immensely valuable tree for afforestation purposes. But it has to be borne in mind that the diameter growths given are for comparative purposes only, and not indicative of rates of growth if the trees are grown under proper forest conditions.

The great age at which the Redwood continues to grow and the greatly increasing rate of annual increment shown by the Redwood at fifty years of age are distinct indications of late maturity, and on no consideration should the Redwood be looked upon as a tree suitable for short rotation, nor could it in any case be profitable to fell trees that were increasing their diameter growth, and therefore very greatly, at an increasing ratio, increasing in annual increment, at fifty years of age. Further, the very fact that the time of maturity, and therefore the time of optimum quality of timber of the Redwood is so remotely ahead of 50 years or even a considerably greater age, indicates that the comparative quality of timber produced by such young trees would be so far below that of matured trees that it is probable that the timber of properly grown Insignis would, from an economical point of view, be more profitable.

Timber.—The timber is light in weight, very soft, brittle, and very durable, and of a red-brown colour.

The above description does not seem to indicate a timber of high quality, but nevertheless the timber of the Redwood is one of the most valuable timbers there is. Whilst it holds no place where strength and hardness are qualities desired, it is of light weight and an exceedingly easy timber to work, and suitable for innumerable purposes, and it is extremely durable under all conditions. It also can be obtained in very large sizes. Tops for the largest of tables and such like can be obtained in one piece.

Directions for planting, etc.—The Redwood remains truer to type than most of the species suitable for afforestation purposes, but, as in the case of all others, seed should be collected only from vigorous well-shaped trees growing under as nearly as possible similar conditions to those obtaining where the trees are to be grown. The seed has a very low percentage of germination. The seed is best raised in comparative shade in somewhat peaty soil. Sowing *in situ* is quite impracticable. The plants are very good transplanters at all times, and should be at least two, better three, or even four, years old when planted out. The Redwood can be raised from root grafts or from cutting—shoots from the base—but such manner of propagation is distinctly undesirable.

There is, unfortunately, practically no recorded information as to spacing, suitable mixtures, and general sylvicultural treatment, but the Redwood, though recorded by some as light-demanding, is a considerable shade bearer, and consequently should be more easily dealt with in mixture.

The young plants are too costly, and thinnings would be of so little value that the necessary density for elimination of side branches and for the growth of good quality close-grained timber should be obtained by planting in "mixture." Underplanting with Redwood could, in some instances, be carried out, but its sensitiveness to soil and climatic conditions, distinctly limits the range of opportunity. Planting in even aged mixture with Macrocarpa is open for adoption in certain situations.

There are several species of valuable trees which, if given several years' start, the Redwood could be planted amongst, but such a course is debarred by the fact that thinning would mean cutting out costly and valuable trees to waste.

Planting with over wide space amongst Larch has been carried out by the New Zealand State Forest authorities, but the effect has not been conducive to the production of high grade Redwood timber.

The Redwood is one of the very few conifers that sprout from the stumps, which it does very freely and repeatedly, from which quality it derives its name *Sempervirens.*

Though the Redwood grows with great vigour in many parts of New Zealand and fairly in some situations in Australia, and also grows in England and on the Continent, it will not grow in America elsewhere than within its natural limited range in the coastal mountains of Northern California. At least it will not grow east of the Rockies.

The Redwood has in growth a slight tendency towards dimorphism in that the seed bearing branches are less spreading than the sterile ones. Several of the Taxads of New Zealand—its allies—have this dimorphic tendency to a very marked degree.

Chapter LII.

PSEUDOTSUGA TAXIFOLIA.

Oregon or Douglas Fir or Spruce.

The Oregon has a very wide range indeed, reaching from the Pacific Ocean to the eastern base of the Rockies, and from Southern California northward through Oregon, Washington, British Columbia, and throughout Vancouver Island.

Through the wide variation of climatic and other conditions within its natural range there are several variations. Those that grow on the western seaboard are better than those growing to the east.

The Oregon grows in "pure stands" and in general "mixed stands," including several of the leading timber trees of the West.

Probably there is no other tree so well known, or timber so widely in use.

Besides being so widely spread, it grows in dense stands of immense trees. An authority places the average size as 200 feet height with a diameter of 4 feet. One tree is recorded as 225 feet high, 14 feet diameter, with a timber content of 125,000 board feet. The Douglas fir has been largely planted for afforestation purposes in many countries. It was introduced into Britain by David Douglas in 1827, and has been more generally planted there than any other American tree.

It has been planted in all our southern lands, but to no great extent in any. It has shown better growth in New Zealand than in either Australia or South Africa, and has done next best in some few places in Australia and very poorly in South Africa.

Climatic and Soil Requirements.—It requires a fairly high rainfall and generally moist and sheltered conditions. It is not very wind firm, and grows best in deep sheltered moist

Douglas fir (*Pseudotsuga taxifolia*) in *Larix europea* stand. Age 25 years.

valleys in deep fertile porous soils and fresh sandy loams, but will adapt itself to poorer soils. Stiff clays, poor sandy or chalk soils do not suit it at all. It will stand colder conditions than the Redwood, but does not like high temperatures or dryness.

Rate of Growth.—The Douglas fir's rate of growth in our southern lands is considerably below that of Insignis and Redwood, but faster—at least so far as New Zealand is concerned—than any other of the softwoods except Macrocarpa.

Sir William Schlich, referring to a plantation in Britain, says:—"In this regular wood, 32 years old, all the trees were excessively tapering, giving a form factor of ·39 for timber only over 3 inches diameter at the thin end, that in 1888, 22 years after, the form factor had risen to ·44. Growth exceedingly fast, at the same time it varies exceedingly according to climate and soil. . . . Eighty year old timber, under most favourable conditions, average height of 133 ft., and an average annual increment of near 20 inches." . . .

"Moreover there are unmistakable indications that the rate of growth is falling off in this country (Britain) at a comparatively early age, and that the timber is not likely to be of the same quality as that imported from America unless the trees are allowed to reach a very great age. There are many failures owing to the tree being planted in cleared ground instead of under shelter."

Our experience of Douglas fir in southern lands is far too short and limited upon which to form any reliable opinion, and it remains to be seen whether a falling off in rate of growth as indicated at Home will occur here.

Timber.—There is, however, one thing certain, that the Douglas fir requires a much longer rotation than seems to be contemplated by planters if timber of anything like the quality of that obtained from matured trees from natural stands is aimed at. The Oregon timber varies very greatly in quality, more so than almost any other important timber obtained from natural supplies. This great variation in quality is doubtless due to a combination of causes, among which its rather fast growth, the different situation in which, and different conditions under which, it is grown, are contributing factors. The timber varies from soft to hard, from rather brittle to fairly strong, and the colour from red to yellow, and even nearly white, and from a timber possessing hardly any durability to one of very fair durability classed at slightly over one-half that of Redwood.

Directions for Growing.—Whether grown in "pure" stand or in mixture, the Douglas fir should be grown densely. If grown in open, or if over widely spaced, the timber will be of distinctly inferior quality. In Britain and elsewhere it has been much grown in "pure" stands, generally closely spaced, the spacing ranging from 3 ft. x 3 ft. to 6 ft. x 6 ft. It will do well in quite a number of mixtures, even aged or used for underplanting, but of course the choice of the species with which to associate it is very dependent on the situation.

It can be associated with Spruce, Western larch, Redwood, Lawsoniana, Western Red Cedar, and many others. But it has to be remembered that it is a fairly light-demanding species.

The Douglas fir has proved itself in many places among the leading trees suitable for afforestation purposes, and it should be preferred to many that have been and are being planted wherever the climatic and soil conditions are suitable.

Considering the cost of the plants and the lack of value in quite young thinnings, the Douglas fir could be spaced quite widely, even up to 16 ft. x 16 ft., sufficient density being obtained by interplanting with some other species, suitable for association and to the situation, which would be of value when comparatively young and when a proportion of such were removed, underplanting, dependent upon the growth of the Douglas fir, could be undertaken. Some such method would have to be resorted to, for there is no advantage in adopting a short rotation period for Douglas fir. Failing the situation and rates of growth being favourable for "mixed" planting then "pure" planting at fair density should be chosen.

Chapter LIII.

THUYA PLICATA.

(Syn. *T. gigantea*).

Western Red Cedar.

The Western Red Cedar, also known as Giant Arborvitae and as Canoe Cedar, is one of the great trees in the land of giant trees. Its range is very wide, reaching from Northern California to Alaska, and extending eastward into Idaho and Montana.

It is far the finest of the Thuyas, and is an exceedingly handsome tree which has long held an important place in connection with arboriculture.

The Western Red Cedar, unlike the Eastern one—Thuya occidentalis, White Cedar—grows to a great size, with an immense spreading deeply flanged or fluted base. The diameter of the base is frequently nearly twice that of the trunk 20 feet up. It reaches a height of 200 feet. The deep fluting and excessive taper is characteristic of these trees as they gain age, and is not a feature of the young trees, the growth of which is fairly rapid, but that of older trees becomes very slow.

It was introduced into Britain in 1853, and in some places there has reached a height of from 70 to 80 feet, but that would be during the period of its most rapid growth, and later growth would doubtless be at a very much less rate.

Simon B Elliott, in *The Important Timber Trees of the United States*, says that it is a fairly rapid grower in early life but that trees from 24 to 40 inches in diameter run from two hundred to five hundred and ten years of age. This information was doubtless based on the results of careful examination, and is so precise that, taken in conjunction with recorded growth of trees in early life in Britain and also of young trees in New Zealand, suggests that Sir William Schlich's statement to the effect that early growth is slow and later very rapid must be an accidental reversal of the position.

In New Zealand the rate of growth when young is much behind the quick growing species, and the rate of growth in some small plantations of it does not indicate much prospect of it proving anyway nearly as profitable a tree for afforestation purposes as the Redwood, which can be grown satisfactorily under similar conditions to those favourable to the Western Red Cedar, except that the latter will stand wetter soil conditions. Under exceptional conditions Western Red Cedar has reached 50 ft. height by 18 inches diameter in 25 years in New Zealand.

Red Cedar thrives best where there is a moist atmosphere, but not near the sea, and although it will thrive in comparatively dry soil, it much prefers wet conditions with a deep rich porous soil or sandy loam.

Timber.—The timber is light in weight, dull reddish-brown in colour, very soft and brittle, easily split, and is considered about as durable as Redwood. It is very bad for nailing, and

requires special flat-headed nails. The timber is suitable for any purpose where a light soft and durable, but *not* strong, timber is required, but Redwood has if anything greater durability, considerably more strength, and is a much better nailing timber, is less variable in density, can be procured in larger sizes, and is a very much more rapid and reliable grower, and therefore should always be planted, where the conditions are favourable, in preference to Western Red Cedar.

The Western Red Cedar is a fair shade bearer, and the side branches, though usually quite slender, are very persistent, therefore quite close planting is necessary, and it is best that the density be obtained by mixture.

So far there is no evidence that afforestation with Western Red Cedar is warranted in any of our southern lands except under exceptional conditions as to situation such as where the soil is over wet for other species. However, some while ago the then Director of New Zealand State Forest Service advocated the planting of it, and further information may indicate better prospects.

Chapter LIV.

TAXODIUM DISTICHUM.

Bald or Swamp Cypress.

The Bald Cypress is so called because it is deciduous. The reason for the name Swamp Cypress is still more obvious, for though it will grow on dry land, it is essentially a swamp grower. It is distributed through the South Atlantic and Gulf States, extending right from the Atlantic coast to Mexico. It grows in wet land, along river banks and in swamps, water covered for months or in the latter case the year through. There are still extensive swamp areas thickly covered with the Bald Cypress.

Where growing in swamps or low-lying land subject to being water covered it develops a wider buttressed base than the Western Red Cedar, and the buttresses extend much higher up the trunk. The roots rise in high knees above the water. When grown on dry land the buttresses are absent, and the trunk rises as a central stem with a steady taper right from the ground.

Size.—It grows in extreme cases to a height of about 170 feet, with a base diameter of up to 15 feet, and above the buttresses a trunk diameter of 5 or 6 feet.

Timber.—The timber is light in weight, and from light to dark brown in colour. It is far from strong, soft, easily worked, and very durable when subject to exposure.

Growth.—The Bald Cypress was one of the very first American trees to be introduced into Britain, but there it has only been grown as an ornamental tree, and rates of growth are not recorded. Trees grown in New Zealand have done fairly well, and there are some few ornamental trees in Victoria and New South Wales. In Cape Town there are trees of some age, and the South Africa Forest Service is testing it for afforestation purposes.

A Bald Cypress grown in New York reached a height of 84 feet and a diameter of 30 inches 5 feet from the ground in seventy-five years. It is reputed to be a rapid grower when young, but very slow as it grows older, in old age taking nearly 20 years to increase an inch in diameter.

There is not yet sufficient information available to show what place this tree may be entitled to, but indications are that its rate of growth in our southern lands is far behind that of other species that will provide timber suitable for similar purposes.

Chapter LV.

LARCH AND SPRUCE.

Larch.—Of the several species the European larch (*Larix decidua*) and the Western American larch (*Larix occidentalis*) are the best known. The Western larch grows to a height of 200 feet in extreme, and a diameter up to 7 feet.

Both the European and Western larch require a fair degree of moisture, neither stand drought, and both thrive best where the mean annual temperature is rather low, and will stand distinctly low, but not very high, temperatures.

Both are hardy, storm firm, and light demanding. Both thrive best in fairly moist but well drained, deep, fairly porous and fertile soils. Though the Western larch will stand the moister condition, neither wet nor over dry nor over hard con-

ditions suit it. The European larch is somewhat the less exacting as to soil conditions, and will grow in clays, but will not continue to thrive on dry, sandy, stony, or thin soils, or in badly drained soils.

Growth.—Both are fairly rapid growers when young, but later slow off very much. They are long lived trees, the Western larch reaching the age of 500 years and over. Trees of 20 inches in diameter, according to Elliott, are from 250 to 300 years old.

Timber.—The timber is, according to the situation it has been grown in and the freedom or otherwise from disease, very variable in quality. Good larch timber is hard, tough, and durable under exposure, but is liable to twist and warp. Its most important uses are for mine props, railway sleepers, posts, poles, etc. If it has been grown in dry soils it is always brittle, and if on thin chalky soil often hollow. The quite young timber is more reliable than older. Grown in our southern lands it is doubtful if any reliance can be placed on the timber being at all equal to its general repute. Timber from a 40 year old larch in New Zealand was found to be distinctly inferior.

Disease.—The larch is exceedingly liable to disease, and its only hope of escape in the south is in the colder, higher, and not dry situations in parts of New Zealand. But even in such, the doubtful quality of the timber and its comparatively low value at the best with other timbers suitable for the same purpose that can be grown, does not seem to warrant the risk.

In any case larch should on no account be planted "pure," and the very extensive planting, some time back, by the New Zealand State authorities can only be termed a huge gamble for an entirely inadequate prize.

The number of larch planted in New Zealand up to a certain time exceeded greatly the total of all other species together.

Neither in Australia nor in South Africa is there any chance of the larch having any place in afforestation.

Many species of Eucalypts will produce better timber much more quickly.

Spruce.

Disease has already quite settled the question as to Spruce in our southern lands except possibly in the colder and higher parts of the South Island of New Zealand. Elsewhere, even if in places it has not already succumbed to disease, the practical certainty of it doing so sooner or later should prevent any attempt being indulged in.

Chapter LVI.

EUCALYPTS AND THEIR ALLIES.

Fortunately none of the southern lands have to look to the Northern Hemisphere for hardwoods for afforestation purposes, Australia being the home of all the hardwood trees that we need grow to any extent.

Fortunately also, most of such, or any way a wide range of valuable species, thrive excellently in both South Africa and New Zealand, especially so in the latter country.

The order *Myrtaceæ* includes some of the strongest, hardest, toughest, most durable timbers and best fuel woods there are, and also some of the tallest and largest trees in the world.

The order is very strongly represented in Australia and Tasmania by several genera, chief amongst which is Eucalyptus, with some 450 species, many of which are most valuable timber trees. Other valuable timber producers belong to the genera Syncarpia, Tristania, and Angophora; and genera of lesser importance are Melaleuca, Eugenia, and Leptospermum.

The Myrtaceæ are represented in New Zealand by the genera Metrosideros (Ratas and Pohutukawas), Leptospermum (Tea-tree), and Eugenia, but none of these, though fine timber trees, are of sufficiently rapid growth to call for consideration for afforestation purposes.

Besides many very valuable species of Eucalypts, Syncarpia laurifolia (the Turpentine) is an exceedingly valuable timber tree, and next in importance to that is Tristania conferta—Brush Box—and of less importance, the other Syncarpias, Tristanias and the Angophoras.

Eucalypts, very commonly called Gums, include, in the great number of species, trees of many forms and varying in size from mere shrubs to the tallest and possibly the largest trees in the world. The greater number are producers of timber of importance.

Whilst the name Gum is, outside Australia, commonly applied to all the Eucalypts, the Angophoras and others, they were from quite early times separated into various classes, somewhat distinguished by their barks or the colour of their

woods, or by supposed resemblance of either the tree or the wood to European trees or woods.

Richard T. Baker, in his valuable work *The Hardwoods of Australia and their Economics*, sets out a practical classification based on the appearance of the bark or of the wood, adopting the names given by early settlers. This grouping and the descriptions are of such practical value that the liberty is taken of setting them out here in full as follows:—

1. Bloodwoods	5. Stringybarks	9. Peppermints
2. Mahoganies	6. Woollybutts	10. Ashes
3. Boxes	7. Blackbutts	11. Ironbarks
4. Tallow-woods	8. Gums	

Description of Barks.

1. Bloodwoods.—In this group of trees the bark is rough, rigid, reddish in colour, friable, and very short in fibre, with medium furrows.

2. Mahoganies.—These have bark almost identical with that of the Stringybarks.

3. Boxes.—This is a more compact, fibrous-ridged bark than any of the previous groups, a light grey in colour, and the lattice pattern much smaller than in the Stringybarks, the furrows less deep than in any other lattice pattern group.

4. Tallow-woods.—This bark is yellow ochre in colour, laminated, and scarcely rigid or furrowed.

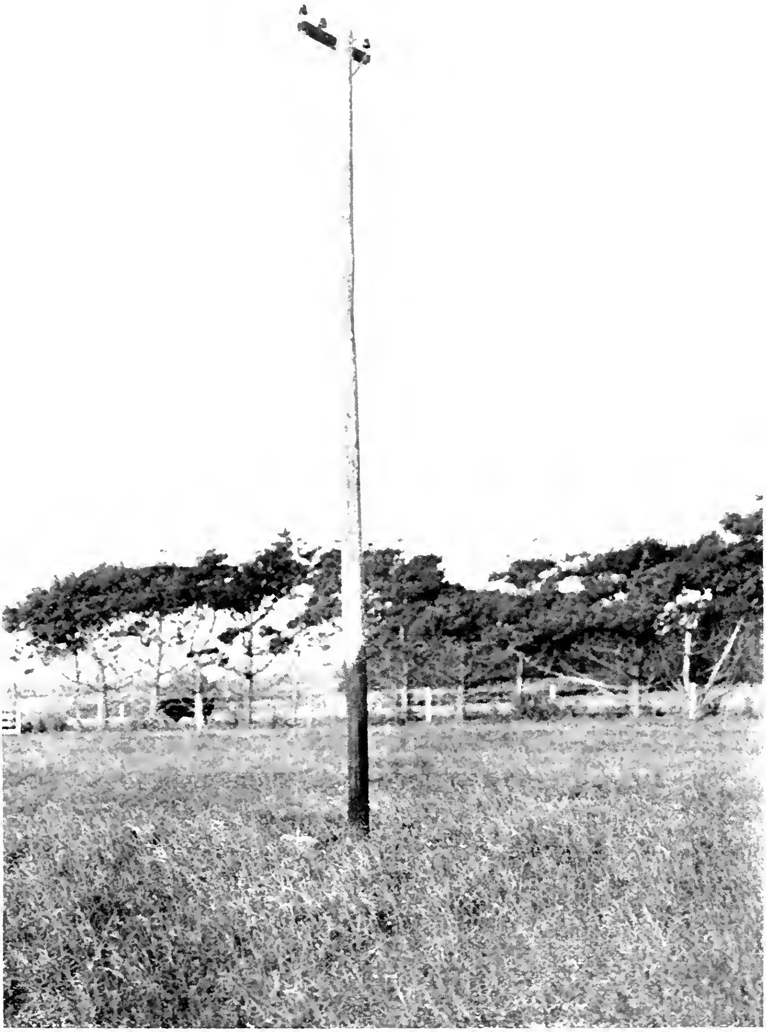
5. Stringybarks.—These are characterised by the long fibres, which intertwine and cross lattice-like, forming ridges and depressions, and are reddish-brown or grey in colour.

6. Woollybutts.—This bark may be described as a coarser kind than any variety of the Box bark.

7. Blackbutts.—These have similar characters to the Stringybarks, only black at the surface, as though burnt, and not extending so far up the trunk or branches.

8. Gums.—The largest group of all, having a smooth, pinkish, yellowish tint, or whitish bark.

9. Peppermints.—These barks might be described as a fine lattice pattern and rather closer in textures than that of the Stringybarks, but shorter in the fibre and the colour, more bordering on that of the Boxes.



Electric-light pole 26 feet high, six years in position and perfectly sound, cut from 15 year old densely grown Taranaki plantation of *Eucalyptus obliqua* (Stringybark).

10. Ashes.—Somewhat similar in character to that of the Blackbutts.

11. Ironbarks.—A hard, rugged, compact, broadly latticed pattern, high ridged bark, either black or grey on the outer surface, and always dark red inside.

Whilst there are valuable timber producers in each group far the most valuable of all are the Ironbarks, and perhaps next to that come the Tallow-woods and Mahoganies.

Many of the Eucalypts are exceedingly rapid growers, and thrive most astonishingly in new homes in many parts of the world, and as a consequence are being very extensively grown in many countries, both in the Northern and Southern Hemispheres.

South Africa has experienced considerable success with several species, and New Zealand with still a greater number.

Though Australia, their home, is a much hotter and generally drier country than New Zealand, many species of Eucalypts seem to thrive better in the latter country than in their natural home. The more moist, and in many parts the more fertile, soil conditions in New Zealand seem to entirely suit them.

Local Names.—Consequent doubtless on the great number of species of Eucalypts and the similarity of the characteristics of many of them, there is a most confusing repetition of common or local names, especially as so many who have to do with the trees or with the timbers are unacquainted with the proper names. An attempt has been made in Australia to do away with this confusing application of the same names to different trees, by assigning a definite name to each, but it is very doubtful whether the object desired will be attained.

Whilst the grouping of Eucalpyts in accordance with their bark characteristics is very useful, the calling of a number of different species by one name, such as, for instance, "Stringybark," of which there are seven or eight so called, is most troublesome. True in some localities they are somewhat distinguished by being called White, Yellow, Brown, Red, Silver-top, and just Stringybark, but even then these distinguishing prefixes are applied to different species. There are some four Mahoganies, some four Red gums, four Mountain Ashes at least, two Blue gums, seven Ironbarks, and seven Eucalypts called Box, as well as a Tristania.

CHAPTER LVII.

EUCALYPTS—THEIR QUALITIES AND REQUIREMENTS.

Timber.—Whilst the timber of the Eucalypts and their allies have so many excellent qualities they have one undesirable one, namely, that of opening and warping when drying, and as a consequence require special and considerable care in seasoning.

Whilst the timbers of old trees, especially those of the better, heavier, denser qualities, consequent on these qualities, do not absorb preservatives well, sap timber and young saplings, or any with a fair amount of sapwood, can be treated with preservatives most satisfactorily.

The preservative saturated sap protects the heart timber from attack by ants, borers, fungus, etc., and makes that of quite young trees outlast that of old trees. This, whilst it may not be of very great importance where plenty of naturally grown mature timber is obtainable, is of exceeding importance in afforestation in connection with which financial and other considerations tend so greatly to make the practical rotation period so very far short of any approach to the age of maturity.

The Eucalypts provide timbers suitable for practically every purpose except for such where distinctly softwood is required. They range from heavy timbers of very great strength, hardness, toughness, exceedingly matted grain and great durability eminently suitable for such work as wharf and bridge construction, all structural work where great strength and durability is required, such as for girders and beams, electric-power, telegraph, and other poles, posts, paving and other blocks, railway ties, and rolling stock purposes, coachbuilders' and cabinetmakers' needs, and innumerable other purposes, to distinctly fissile, easily worked timbers of light weight, some very durable and strong, also suitable for poles, etc., building, furnishing, and endless other purposes.

Many of the Eucalypt timbers are exceedingly beautiful in grain and colour. Some are among the most handsome woods in the world.

There are so many beautifully grained and coloured woods of the Eucalypts that it is hard, considering varying tastes,

to make a selection, but certainly among some of the best are the following:—

Red Mahogany (*E. resinifera*), especially the figured timber, Jarrah (*E. Marginata*), one of the Boxes (*E. Polyanthemos*), another Box (*E. Rudderi*), Wandoo (*E. redunca*), York Gum (*E. loxophleba*), Yate (*E. cornuta*), Slaty Gum (*E. Dawsoni*), Salmon Gum (*E. Salmonophloia*), Murray River Red Gum (*E. rostrata*), Woollybutt (*E. longifolia*), Spotted Gum (*E. maculata*), Mountain Gum (*E. gonocalyx*), Stringybark (*E. obliqua*), Brown Stringybark (*E. capitellata*), a Mountain Ash (*E. Delegatensis*, syn. *gigantea*).

Several species of Eucalyptus, when quite young, say from 12 to 18 years of age, supply timber quite suitable for most purposes for which "Softwood" is required, including pulping. *Euc. saligna* and some of the "Stringybarks" and "Gums" are particularly suitable.

Climatic and Soil Conditions.—Speaking broadly it may be said that the Eucalypts adapt themselves to a very wide range of climatic and soil condition. Some species will stand high temperature and low rainfall, others will stand very considerable cold and many degrees of frost, also heavy rainfall, and whilst it is obvious that those species that will stand the one set of extremes will not stand the other, practically all will thrive under moderate climatic conditions, and the greater number grow with the greatest vigour and reach their greatest dimensions where there is moderate warmth, a fairly high rainfall, and moist, though not over wet, soil conditions—and atmospheric moisture.

Soil.—Some species, and among them some very valuable ones, will grow on hard stony poor land, such as hard stony ridges, and others will grow in almost pure sand if fairly moist, but well drained, deep, fertile porous soils, such as good fresh sandy loams, with suitable climatic conditions, are the most favourable to far the greater number of species, and result in a much more rapid rate of growth and much greater ultimate dimensions than would be attained by the same species in harder poor soils and great extremes of climatic conditions.

Whilst a limited number of species will grow almost anywhere where the conditions are moderate, many others are most sensitive as to particular situation. Quite a few miles will cause a great difference in the degree of vigour and rate of growth.

It is more important with Eucalypts than any other class of trees that, with the exception in the case of one or two reliable species, proper experimental areas should be established and results watched before any considerable planting of other species is carried out, that is unless it chances that sufficient knowledge of their suitability or otherwise in the particular situation is obtainable.

Whilst some afforestation with Eucalypts has been carried out in parts of Australia, such as in South Australia, the amount is not extensive consequent on natural supplies.

In many parts of New Zealand many Eucalypts have found apparently optimum conditions conducive to exceedingly vigorous and rapid growth, and therefore it is surprising that although there are a great number of quite small plantations very little extensive planting has been carried out so far, and practically all of it has been "pure" planting.

The wide range of conditions in, and the proportionately great length of, coastal areas of New Zealand, the cooler conditions of the south and of the higher lands, and the considerably warmer conditions of the north, permit a wide range of choice of species, among which are many very valuable ones.

South Africa has for quite a number of years used various Eucalypts for afforestation purposes, and has met with much success. Amongst those which have been successfully grown are such valuable species as paniculata, maculata, saligna, resinifera, microcorys, sideroxylon, polyanthemos, rostrata, diversicolor (Karri), corynocalyx (Sugar Gum), and Maideni. The latter has been very extensively planted, and is proving a very valuable tree for afforestation purposes.

Climatic conditions in some parts of South Africa seem more favourable to successful growth of some valuable species than in New Zealand, except within quite restricted limits.

Propagation, Sylvicultural Treatment.—There are so very many local variations of different species of Eucalypts, and such a great difference in the quality of the timber in these variations, that it is more important in the case of Eucalypts than in that of any other class of trees that the seed should be most carefully selected, gathered from only the very best type of tree, growing where it is not in association with inferior trees of its kind, or with other variations or species, and where the conditions are as near as reasonably possible to those of the situation where it is intended to grow trees from it.

Where weed and soil conditions will permit of successful raising of the seed *in situ*, such will doubtless result in raising better trees and at less cost than raising the seed in beds and planting out, but the conditions are rarely favourable to raising Eucalypts *in situ*; however, there are some species, such as the Sugar Gum (*E. corynocalyx*) and the valuable Yate (*E. cornuta*), which are exceedingly difficult to transplant, and warrant, therefore, extra trouble and expense, if conditions require them, in raising of the seed *in situ*, either by ploughing the land or otherwise thoroughly preparing it, if it is not naturally clean, drilling in or "spot sowing" the seed, and keeping the seedlings clean in the plantation until safe from any weed or other growth.

Eucalypt seed should be sown, when to be raised in the nursery, in narrow rows sparsely, so that the seedlings will be well rooted, sturdy, thick stemmed, and not spindly. They should be properly wrenched, and the re-growth started on the roots before lifting. Exceeding care should be taken with the seedlings at all times, when lifting, grading, counting, taking out to the plantation, and planting, that they are exposed as little as possible to the sun or wind, covered as soon as possible, and on *no account* let get dry. Instead of a normal percentage of failures ranging from 2% or 3% to say 15% at most, if once the seedlings are let dry the percentage of failures will rise to two or three or even four times as much.

The care and treatment of Wattle seedlings should be similar to that of Eucalypts, though they are not quite so sensitive.

Spacing.—Whilst many of the Eucalypts naturally grow with long straight clean stems and from that fact and that they are very light demanding, wide spacing has usually been adopted, overlooking the fact that wide spacing permits exceedingly rapid diameter expansion, especially so in situations favourable to full development. The result is that in New Zealand, where the conditions are often exceptionally favourable, they attain, as for instance when required for light and telegraph poles, dimensions, in a few years, before the timber has either strength or durability, far in excess of what is required.

Eucalypts, especially where the conditions are favourable to rapid growth, are no exception to the fundamental rule that applies to other trees, which is that to grow dense, strong high grade timber you must plant densely. The fact that the timber of some species of Eucalypts obtained from trees grown

in over open stands has proved of the very best quality, provides no evidence whatever against close planting, because such are generally found growing in hard stony ridges or other conditions unfavourable to anything but very slow development. The same species grown in, say, New Zealand, under favourable conditions, will attain the same size in less than a quarter of the time.

Spacing of 6 to 8 feet for Eucalypts is far too open. Of course the space requirements vary greatly with the different species. Some heavy foliaged species with the leaves set laterally, require a fair amount of space, whilst others such as *E. gigantea*, syn. *Delegatensis*, with vertically set leaves, will grow very densely. Gigantea is naturally a very dense growing tree, the densest of all the Eucalypts.

If the seed is selected and the plants good and properly graded and planted, a stand should be of fairly even height, which will tend greatly towards lessening early and extensive natural suppression, but in any case it is better to plant densely, even at the expense of fairly heavy natural suppression taking place before systematic thinning is undertaken.

If planted according to the system earlier explained, of alternate double spacing, that is the plants in every second row being set opposite the centre of the space between the plants on either side and the plants in the rows being set at double the distance of that between the rows, a spacing varying to suit the species of from 7 ft. x $3\frac{1}{2}$ ft. to 6 ft. x 3 ft., or nominally 1,778 to 2,420 per acre, but allowing for failures, bad trees, and natural suppressions, say 1,600 to 2,200 per acre. If every alternate row is cut out when large enough for light-weight poles there would be 800 to 1,100 per acre, spaced generally at 7 ft. x 7 ft. to 6 ft. x 6 ft., left to grow into heavier timber.

If after thinning or at any time later a stand of Eucalypts becomes too open and the forest floor is unduly exposed, "under planting" with pines of one kind or another suited to the situation can be undertaken. According to the situation Insignis, Macrocarpa, Canary Pines, Pinaster, Redwood, Lawsoniana, and others can be used.

Eucalypts can be grown most successfully planted in mixture with other species of Eucalypts, with Pines, with Wattles, and with Pines and Wattles, but full knowledge of the relative rates of growth in the locality under quite similar conditions is essential. Mixing Pines and Wattles with Eucalypts is very

beneficial where the conditions are favourable to both, in that, more complete cover to the forest floor is obtained, and continues to be maintained, and soil fertility is maintained. It is important to remember that not only are a great number of the species very sensitive at all stages of growth to the local conditions, very greatly varying in vigour of growth in apparently quite, or almost, similar situations within only a few miles of each other, but the young plants are exceedingly sensitive as to soil conditions. The plants of one species will grow freely right from the first, and soon be well beyond risk of damage by weeds, etc., whilst those of another species, will, under certain soil conditions, be very slow in starting, and consequently a heavy percentage is liable to be destroyed or seriously retarded, resulting in uneven height growth and an irregular and gappy stand. For such, special treatment is necessary, such as cultivation and the use of nothing but first grade plants.

Chapter LVIII.

EUCALYPTS—SELECTION FOR AFFORESTATION PURPOSES.

The object of this work is that of somewhat generally indicating what may be of assistance in afforestation operation and the adoption of sound practices, and does not aim at complete detailed information on any branch of the very many embraced under the general designation of Forestry, or such as are associated with it. When exact and full information on any particular subject is required direct reference to works dealing with it specially is advisable.

As in the case of the numerous species of Eucalypts, reference to special works dealing with them is the only advisable course. Such works as the *Critical Revision of the Genus Eucalyptus*, and *The Forest Flora of New South Wales*, by the late J. H. Maiden, I.S.O., F.R.S., F.L.S., deal with the scientific classification, general description, size, growth, habitat, qualities, and uses of their timbers. A work by Richard T. Baker, *The Hardwoods of Australia and their Economics*, contains a wealth of valuable information as to the qualities and uses of the

timbers. A valuable work by the Rev. J. H. Simmonds, recently published, *Eucalypts in New Zealand*, contains much general information as to Eucalypts and their allies, and as to their presence and growth in New Zealand.

So many are the species, and so important, and so varied are their qualities, etc., that they cannot be adequately dealt with except in a special work.

Only a few species which are either generally suitable, or of which there are reasonable prospects of their proving to be so, will be referred to here.

Grouping.—There are several systems of grouping. One, already given, based on the different barks or on what is really the superficial appearance of the stems. Another on the qualities of the timbers, and again on the uses of the timbers. And yet another on the climatic needs and limitations of the trees.

Towards the end of the work *The Hardwoods of Australia and their Economics*, by Richard T. Baker, already referred to, there are two very full and valuable group lists, namely "Australian Substitutes for some Exotic and Imported Hardwoods," and "Trade Applications of Australian Hardwoods." From these very complete information as to all qualities and uses of such can be obtained.

For general afforestation purposes a selection of species which produce more or less valuable timber, which grow rapidly or reasonably quickly, and which offer reasonable prospects of success in afforestation undertakings, seems the most desirable one that is practicable within the scope of this work.

Species of which the qualities, requirements, and behaviour under afforestation conditions are unknown or anyway are unknown to the writer, also such as are of distinctly poor quality, either in manner or growth, or as timber producers, and also such of which there are no available indications that they can be profitably grown under afforestation methods, are left out, consequently the number is very restricted compared to the number of those generally included in such lists. For instance, a usual list of frost-hardy Eucalypts would include coccifera, coriacea, urnigera, Muelleri, Gunnii, and delegatensis, syn. gigantea. But there is no good purpose to be served by including the first three or four species, seeing that they are distinctly slow growing, of ill-shaped growth, and of no particular value.

Those in the following list are arranged in groups, from the thoroughly frost hardy to such as are distinctly frost tender, but the grouping can only be approximate, as, for instance, the different types of the same species will vary greatly as to hardiness.

CLASS 1.

Frost Hardy.

Euc. Gunnii—Cider Gum.
Muelleri — Brown Gum, syn. *Johnstoni.*
gigantea, syn. *Delegatensis* —Red Mountain Ash.

CLASS 2.

Fairly Frost Hardy.

Maideni {Maiden's Gum. / Spotted Blue Gum.
fastigata—A Stringybark.
Macarthuri — Camden Woollybutt.
ovata—Swamp Gum.
obliqua—Stringybark.
oreades, syn. *Luehmanniana*, var. *altior.*
Sieberiana—Silver-top.
Blaxlandii—Blue Stringybark.
regnans—Giant Gum.
viminalis—Manna Gum.
amygdalina, var.—Tasmanian Black Peppermint.
Smithii—Gully Gum.

CLASS 3.

Slightly Frost Hardy.

Bosistoana—Bosisto's Box or Red Box.
botryoides—Bangalay.
saligna—Sydney Blue Gum.
pilularis—Blackbutt.
resinifera—Red Mahogany.
eugenioides — White Stringybark.
Mulleriana—Yellow Stringybark.
capitellata — Mountain Grey Gum.
rostrata—River Red Gum.
tereticornis — Forest Red Gum.
goniocalyx—Mountain Gum.
sideroxylon—Red Ironbark.

CLASS 4.

Very Slightly Frost Hardy.

microcorys—Tallow-wood.
paniculata—Grey Ironbark.
siderophloia — Broad - leaved Ironbark.
diversicolor—Karri.
acmenioides — White Mahogany.
corynocalyx—Sugar Gum.

CLASS 5.

Frost Sensitive.

marginata—Jarrah.
cornuta—Yate.
loxophleba—York Gum.
salmonophloia—Salmon Gum.
Jacksoni—A Stringybark.

IMPORTANT ALLIED TREES.

Syncarpia laurifolia — "Turpentine."
Tristania conferta — "Brush Box."

List of Eucalypts referred to later, placed in the Approximate Order of their Rate of Growth.

fastigata	gigantea	Muelleriana
obliqua	rostrata	paniculata
ovata	oreades	acmenioides
regnans	pilularis	sideroxylon
Maideni	Blaxlandi	corynocalyx
botryoides	Smithii	goniocalyx
saligna	Bosistoana	tereticornis
Macarthuri	eugenioides	piperita
viminalis	resinifera	Gunnii
Sieberiana	microcorys	Muelleri
cornuta	capitellata	marginata
amygdalina. Tas. var. Black Peppermint	diversicolor	siderophloia

---

Chapter LIX.

CLASS I—DISTINCTLY FROST HARDY EUCALYPTS.

Eucalyptus Gunnii (Cider Gum).

The Cider Gum is undoubtedly quite the hardiest—that is the greatest frost resister—among the Eucalypts.

It grows as far south as the extreme south of New Zealand, and therefore will stand any degree of cold to be met with in any parts except at the highest elevations of our southern lands.

The Cider Gum is a native of Tasmania, and there belongs to the higher mountain parts.

Its value as a tree for afforestation purposes is its extreme hardiness, and its use should be restricted to quite the coldest parts of our southern lands where none of the better quality or faster growing gums can be used.

Size.—The type when growing in exposed positions is that of a heavily branched somewhat stunted tree, but it will grow to over 100 feet in height, and well over 2 feet in diameter with a straight bole, but if the growing of such trees was aimed at the seed would have to be collected from the best trees of the best type, and the situation would have to be favourable. In

one instance heavy limbed short stemmed trees of 4 feet diameter are recorded.

Growth and Timber.—Both as to rate of growth and durability there seems to be a great conflict of opinion, very much of which doubtless arises from a great confusion between several species, viz.:—Gunnii, acervula, ovata, paludosa, and Stuartiana. When buying seed through ordinary channels, no matter which name you order under, you are as likely to get any one, or even a mixture, of the others. So there is added to the confusion of the different species by the bushmen the wrong impressions formed by judging rate of growth and quality of timber of trees grown under a wrong name.

The timber of mature trees of the true Gunnii is hard, heavy, and said to be durable, and although that of comparatively young trees grown in Otago (N.Z.) has gained a reputation of being fairly durable, that of young trees grown elsewhere is not held in much repute. Anyway the timber does not rank as one of high quality, and as, with some exceptions, Gunnii is of slow growth, it can only be valued as a frost resister.

Eucalyptus Muelleri (syn. *Johnstoni*).

Mueller's Gum or Mountain Red Gum.

Mueller's Gum is a native of inland Tasmania, and is one of the hardiest frost resisting Eucalypts, and as such may have a place in afforestation operations in the higher elevations and coldest parts of our southern lands.

Whilst the Cider Gum ranks first as a frost resister, it is an inferior tree to Mueller's Gum.

Size.—Very much larger and finer proportioned tree than Gunnii. It reaches, in extreme cases, 200 feet in height and over 3 feet in diameter. It grows, under suitable conditions, as a central stemmed tree with straight clear bole.

Growth and Timber.—Very little information is obtainable as to the rate of growth of Mueller's Gum, and what there is does not indicate other than that it is a slow grower. It has been very little planted, which is probably due to the distinctly slow growth it has made in some places. However, it would seem worthy of giving a thorough trial wherever the conditions are too severe for successful growth of more rapid growing species of value.

Matured timber is hard, strong, heavy, and durable.

Eucalyptus gigantea (syn. *Delegatensis*) in Experimental Area at the Taranaki Forests Plantations. The central trees are *Gigantea.*

Eucalyptus gigantea (syn. *Delegatensis**)

Mountain Ash or Gum-topped Stringybark.

The Gigantea, by which name it is best distinguished, was at one time the predominating tree of the uplands of Tasmania. There it was found in great numbers and density. It is also found at high elevations in Victoria and New South Wales.

It is closely allied to the Stringybark (*E. obliqua*), and has been looked upon as a mountain variety of it.

Whilst young it is very easily distinguished from the Stringybark by its much broader pale grey-green leaves during early years, later followed by less oblique and somewhat narrower leaves than those of the Obliqua. Whilst the bark of the Obliqua is thick, woolly, and stringy right up the stem and along the limbs, that of Gigantea is similar for about half the length of the trunk, above that the bark is smooth, pale bluish-grey or whitish, the old bark comes off in long thin strips.

Size and Form.—The Gigantea is one of the great trees of Australia and Tasmania. Although the high snowy table-lands are its chief natural home, it attains to far its greatest dimensions on the lower hill slopes and in deep gullies where trees are said to have been found up to 300 feet in height and of very great diameter, some trees reaching nearly 30 feet. Its ordinary dimensions are somewhat about half those mentioned.

The Gigantea is at all stages straight growing. The boles are remarkably fine, quite clean of branches to a great height.

Rate of Growth.—Doubtless at high elevations the Gigantea is not a very fast grower, but under less severe conditions it is distinctly rapid growing, though not so rapid as several other species of Eucalypt, such as *E. fastigata*. Seedling transplants will reach 14 to 16 feet in three years, and such growth ensures early freedom from damage by weeds, etc. The growth later in life is slower.

Timber.—Though not so valuable a timber from point of view of great strength and durability as some of the Ironbarks and some others, it is a timber of very good value, having many favourable qualities and of very wide utility. It is exceedingly light in weight, quite the lightest of all the Eucalypts. The weight ranges from 28 lbs. to 42 lbs. per cubic foot against 70 lbs. and over for Ironbarks. The next lowest in weight to that of Gigantea are Regnans, Obliqua, and Oreades. Not-

*There are marked differences between the Tasmanian and the New South Wales forms which would seem to warrant separate names.

withstanding its very light weight the Gigantea timber is stronger than European Ash, and nearly 50% stronger than Spruce, and therefore where lightness and strength combined are required the timber of the Gigantea is exceptionally serviceable. It is straight grained and easily worked, bends well, has good resilience, and yet is hard, close-grained, and dresses well, and when properly seasoned does not warp.

The timber has much the appearance of English Ash, and therefore its other name, "Mountain Ash."

It is distinctly durable, but there are very conflicting accounts as to the degree of durability, which very likely arise from the timber being confused with others of somewhat similar appearance. It is credited with being quite sound after being in use for well over 30 years as girders, beams, bed-plates, house blocks, weather boards, etc. There seems little doubt that properly grown Gigantea will produce a timber of very considerable durability. The timber has a very wide range of utility, and is especially serviceable for a number of purposes, such as any purpose where bending timbers are required, handles, oars, shafts, etc. It has been specially tested and highly approved for use in parts of aeroplanes.

Situation.—Though the natural habitat of the Gigantea is elevated table-land and high mountain, it thrives well and grows to great size on lower slopes and in gullies; it also thrives in quite low country, whether semi-coastal or inland, so long as temperatures are not high and the conditions are not too dry. It has thriven and grown rapidly in several parts of the North Island of New Zealand, such as at Rotorua. It has not been extensively planted, so that there is a lack of precise information as to the conditions most suitable to it when used for afforestation purpose, but from the way it has thriven under various conditions it does not seem to be at all sensitive except as to heat and dryness.

Sylvicultural, etc.—The seed has a much higher percentage of germination than is frequently displayed by its near associate, Stringybark, and springs readily and in great quantities where naturally sown and elsewhere. Though not appearing to be very well rooted the seedlings transplant well, and have the advantage that through their very broad, pale grey-green leaves the plants are very conspicuous, which greatly facilitates any necessary cleaning.

None of the Eucalypts grow in such density naturally as the Gigantea, and when planted for afforestation purposes the plants should be spaced more closely than any other. Their

tendency under any conditions is to grow with straight central stems, but their vertical leaves, sparse branching, and open foliage make them the least light obstructing, therefore unless very densely planted the forest floor is over exposed. If systematically planted, the straightness of their stems and sparse branching makes the relieving of the density as necessary from time to time, quite free of difficulty, and the form and quality makes the light weight pole thinnings serviceable.

The openness of the forest floor makes under-planting at a later stage most desirable.

The qualities of hardiness and frost resisting, the rapid growth, durability, strength, lightness of weight, and the very wide utility of the timber and the facility with which plantations can be raised makes the Gigantea one of quite the most valuable trees for afforestation purposes for the production of a general purpose wood, including many uses to which softwoods are usually put, and also all to which hardwood are, except where especially high degrees of hardness and durability are required.

Chapter LX.

CLASS 2—FAIRLY FROST HARDY EUCALYPTS.

Eucalyptus Maideni (Maiden's Gum).

Maiden's Gum is one of the most valuable, if not the most valuable, Eucalypt for afforestation purposes. Its exceedingly rapid growth, hardiness, and high qualities of the timber entitle it to a pre-eminent position for afforestation.

It grows at fairly high altitudes in South-eastern New South Wales and Eastern Victoria, and is, by comparison with most, a distinctly rare tree, and until recently very little known, though in South Africa it has been planted to a considerable extent with most satisfactory results.

Its exact place as to degree of hardiness is not yet clear for lack of wider experience, but it is distinctly hardy, and it may be that it should be placed after Gigantea in Class 1. However it is entitled anyway to first place in Class 2.

Size and Nature of Growth.—Maiden's Gum is a very straight growing central stemmed tree of large size, reaching

200 feet or more in height and up to 4 feet and over in diameter. Though such a fine tree it has not come into prominence in its native home, doubtless because of its scarcity and somewhat inaccessible location.

The juvenile leaf-form is large round or somewhat heart-shaped, the mature form is long and narrow.

Rate of Growth.—Maiden's Gum is an exceedingly rapid grower. When it is growing in a suitable position it is very doubtful whether any other Eucalypts exceeds it in rate of growth or perhaps even equals it. In South Africa stands have reached an average height of 94 feet and average diameter of over 12 inches in 18 years, 89 feet by 10 inches in 13 years, and 66 feet by 7 inches in 11 years. At the Taranaki Forests, near New Plymouth, N.Z., Maideni has grown to 26 feet by over 3 inches in three years, and in every way gives great promise.

Timber.—The timber is somewhat of a pale yellow colour, rather streaky and not conspicuous for beauty. It is very strong, hard, heavy, tough, and matted in grain, has considerable elasticity, and is very durable. Quite young trees, 8 to 10 years old, when treated with preservative, are durable, and are strong enough for poles.

When properly grown the timber is remarkably free from knots and gum-veins, dresses well whilst green, but is very hard when seasoned. It is a most valuable timber suitable for piles, girders, beams, power-poles, fence posts, etc.

The weight of the timber is about 50 lbs. to the cubic foot.

Climatic and Soil Conditions.—So far as the little experience there is of it in connection with afforestation, which is mostly confined to South Africa, Maiden's Gum is more suitable to the higher and cooler parts and moister conditions than to drier and hotter. A rainfall from 30 inches upwards, with somewhat moist atmospheric and soil conditions would seem to suit it best.

Whilst it may do in poorer and harder soils, it certainly thrives most surprisingly in free sandy loams and in deep friable clay-loams.

Sylvicultural, etc.—The seed is a free germinator, and the seedlings grow easily and rapidly, and are excellent transplanters. The young trees are densely shade giving during the period they retain their very large broad juvenile form of

foliage, and give good cover to the ground, but after the third year when the juvenile form changes to the mature they are less shade giving. The Maideni would seem to stand more shade than many of the Eucalypts will, but knowledge as to what degree of shade and at what density it is advisable to plant it is lacking. In South Africa, where in parts it has proved such a great success, it would seem to have been planted over openly, but the poles grown are very straight, and have little taper, but that is more likely due to the natural persistency towards a straight central stem. It is probable, however, that the open planting has been at the expense, to some degree at least, of strength and quality of the timber, the open planting permitting over rapid diameter growth.

It is better to err on the side of density and thin as required than to run the risks of over open planting.

Systematic experiments, which include the question of proper density, and of which Maideni is one of the species dealt with, are being carried out at the plantation, near New Plymouth, of the Taranaki Forests.

Eucalyptus fastigata (''Stringybark'' or ''Cut-tail.'')

Fastigata belongs to the higher lands of Victoria and New South Wales. It has been much confused with Obliqua—the Stringybark—and with Regnans—the Giant Gum—and was until comparatively late years classified as a variety of the latter.

Though much resembling Obliqua in some respects it is easily distinguished from it. The bark of the lower part of the trunks of both trees is very similar, but whilst the thick bark of the Obliqua continues right up the stem and along the main branches, that of fastigata only continues part way, and long strips of loose bark are seen hanging to all upper parts of the fastigata. The seed capsules are very small compared with those of the Obliqua.

The fastigata is an exceedingly hardy tree, standing quite a heavy degree of frost and much exposure and generally severe conditions. It thrives best in cooler and moister situations than in hotter and drier, but it is one of the very least sensitive of the Eucalypts to climatic or soil conditions so long as not too hot or too dry.

Size and Form.—Fastigata grows to a large size, over 150 feet in height and possibly very much more, and several feet in diameter. It forms an exceedingly handsome tree, especially so when grown independently, for then it has a wide spread of branches with a mass of drooping foliage.

It has a much greater tendency than a good type of Obliqua to throw out large limbs, and for timber growing this tendency has to be checked.

Rate of Growth.—The Fastigata, it is almost safe to say, ties with E. Maideni as the fastest growing of all the Eucalypts, if not of all trees. Its rate of growth in some situations is astounding.

In the plantations of the writer 7 years old Fastigatas have reached 50 feet and over in height and 7 inches in diameter b. h., 15 year old trees 70 feet hight and 1 foot 9 inches diameter b. h. At the plantations of the Taranaki Forests 32 months old as much as 27 feet in height.

The Rev. J. H. Simmonds records that numerous trees at Papakura, near Auckland, had when 32 years old reached 100 feet in height and 3 to 4 feet diameter.

Timber.—The timber of Fastigata is very straight grained, fissile, easily worked, strong and durable, or fairly so. It is an excellent general building timber, and serves many other purposes. If grown properly it will undoubtedly make excellent poles, especially so if treated with preservatives.

There is some doubt as to its degree of durability, which no doubt arises from the timbers of this species being confused with that of Regnans. Both the trees and the timber of each are somewhat alike in appearance. So far as experience goes in New Zealand it indicates that the timber of Fastigata is durable. Its weight is about 56 lbs. to the cubic foot.

Sylvicultural, etc.—The percentage of germination is high, the seedlings thrive well and transplant very well if properly raised and handled. The transplants get away from the weeds early and grow exceedingly rapidly, which greatly facilitates the establishment of a good, full, even stand.

The tendency of the Fastigata to branch and throw out heavy limbs makes close planting imperative. If planted densely in pure stand or in dense mixture it will grow as a very straight central stemmed tree without any limbs for a very long way up, giving a very long perfectly clean bole.

The Fastigata grows well in mixture with Wattles and Pines.

Dense planting not only insures long lengths of clean timber but it will ensure greater denseness and so greater strength and durability.

Fastigata is certainly one of quite the most valuable of the Eucalypts for afforestation purposes.

Eucalyptus Macarthuri ("Camden Woollybutt.")

Macarthuri belongs to a rather restricted area in South-eastern New South Wales. Its natural habitat is fairly high land where there is plenty of moisture. As a timber producer Macarthuri did not receive recognition in its natural home, and as such only came into notice by the discovery in New Zealand that the timber of trees grown in the Waikato was very durable in contact with the ground.

Macarthuri has proved very hardy and stands as much as 10 or even 12 degrees of frost.

Size and Form.—In especially favourable situations the Macarthuri attains fairly large dimensions, reaching a height of 130 or 140 feet, but usually it is of considerably less size. The young plants are very straggly, and for a few years it is very crooked growing, much branched, and somewhat drooping, but later a somewhat straighter central stem starts. At no time is it a very straight growing tree, the stems usually being more or less irregular.

Rate of Growth.—Macarthuri is a very rapid grower, especially so when comparatively young. Whilst the comparative rate of growth of different species will vary very considerably as the situation is more or less favourable to one or the other, Macarthuri may, where the situation favours it, be reckoned among the first six or seven most rapid growing Eucalypts. The only fault in connection with the rate of growth is the delay in getting away from sprawling seedling form. Trees attain full pole size in 10 to 15 years.

Timber.—The timber is hard, dense, strong, and distinctly durable. It will split, but it does not do so very easily. In grown trees there is very little sap wood, and it makes excellent fence posts, and would make very strong and durable poles for telegraph or power, but has the drawback of cracking badly when drying unless cut at the right time of the year and seasoned carefully. The timber is so good otherwise that it is worth care to overcome this fault. Proper treatment with preservatives after careful seasoning would render them very

lasting poles. The weight of the timber is about 56 lbs. per cub. foot.

Climate and Soil.—As already stated Macarthuri is very hardy, and stands very considerable frost. It is much more at home when the heat is not great and where the soil and atmospheric conditions are moist. It thrives wonderfully where practically throughout the year there is very considerable moisture in the soil. Though the Macarthuri will grow fairly well in semi-coastal situations so long as the conditions are not dry, it is much better suited inland.

It distinctly prefers fertile, deep, porous soils, and is not at all suited to poor and over hard soil conditions.

Sylvicultural, etc.—The seed has very high germination, and the seedlings grow freely in good well cultivated soil. The seedlings transplant well if well rooted and not over large, but the young plants are troublesome as to weeds because of their almost prostrate early habit of growth. Dense planting either in pure stand or in mixture is essential if even moderately straight timber is desired, and too heavy diameter growth is to be prevented.

If the situation is distinctly favourable to the Macarthuri it can be grown very well in mixture with pines and wattles. Mixing with other species of Eucalypts may be undertaken where the rate of growth of each species in the particular situation is known, but for success a distinctly shade giving species would have to be chosen to mix with the Macarthuri.

Eucalyptus Ovata.

Ovata belongs to both Tasmania and the mainland of Australia.

There is so much confusion between Ovata, Acervula, Stuartiana and Gunnii, both as to the trees and the timbers, that it is exceedingly difficult to gather reliable information as to any one of the species. Further, in each species there are very considerable local variations in size and form anyway, if not actually in the quality of the timber.

Where it is intended to use Ovata for afforestation purposes exceptional care should be taken that the seed used is true Ovata seed and unmixed, and that it has been collected from the very best type trees.

Ovata growing in poor land is a much-branched, ill-shaped, shrubby tree, but grown in favourable situations it is a straight

or fairly straight clear stemmed tree, reaching to as much as 100 feet in height, though usually to between 60 and 80 feet, and a diameter of about 2 feet. Much greater diameters—four feet and over—are credited to it, but there is no certainty that such trees were really Ovata.

Ovata is very hardy indeed, and stands a considerable amount of frost, and its value as a tree for afforestation purposes is limited to its use in situations where hardiness is essential.

Growth.—It is a very rapid grower, but in most instances plantations of it display great irregularity in rate of growth which there is little doubt is due to mixed seed.

In the plantation of the writer 20 year old trees are from 60 to 80 feet high and from 1 foot 6 in. diameter b. h. The Rev. J. H. Simmonds records that 25 year old trees are 70 to 90 feet high by 1 ft. 6 in. to 2 ft. diameter.

Timber.—The timber is hard, dense, tough, durable, difficult to split, and is of great strength, ranking about fourth of all the Eucalypts. It is of fairly wide utility, and that of the right type of Tasmanian Ovata is suitable for telegraph and electric power poles and such like.

Climate and Soil.—A moist cool climate and fairly good deep moist soil suits it best. In New Zealand it has been very widely planted, though not in quantities, and there it seems to adapt itself to a wide range of conditions. Though higher and cooler parts appear to be its natural habitat, it thrives excellently in low country, and where the land is inclined to be over wet, and it has as a consequence been given the name of "Swamp Gum" in some places.

Sylvicultural, etc.—In case of this species selection of seed is most important. It is a very free seeder, and the seed has a very high germination. It stands transplanting well. It is not a fast grower at first but after being well established grows rapidly. It does fairly well either in "pure" or "mixed" plantation, but it is a somewhat difficult species to deal with because of the irregular rate of growth. It requires dense planting in the first instance, but even if openly planted, it being a heavy branching headed tree, the irregularity in rate of growth results in a very large proportion being badly retarded in growth or then killed out. In mixture a considerable number of natural suppressions take place. Some quality of mixture may be discovered which will tend to getting better

results. However, towards any improvement careful seed selection is the first step.

For farmers Ovata holds a distinct place in the woodlot or even in shelter belts, but, as has already been indicated, its place in afforestation is where better Eucalypts will not thrive as well.

Chapter LXI.

CLASS 2—FAIRLY FROST HARDY EUCALYPTS (Contd.)

Eucalyptus obliqua ("Stringybark" or "Broad-leaved Messmate").

Eucalptus obliqua is most commonly known as "Stringybark," especially so in Tasmania, but in Victoria it is fairly commonly known as "Messmate," or to distinguish it from the other Messmates, as Broad-leaved Messmate.

The Stringybark has a wide distribution throughout Tasmania and all southern parts of Australia, except the West. It is general throughout Tasmania, where it is one of the commonest, greatest, and most important trees. It occurs throughout Victoria except in the north, and is there an important tree, but less so than in Tasmania. In South Australia it is restricted to the higher land. In New South Wales it occurs in many parts from the south to near the northern boundary, but is restricted mostly to the higher lands, and is neither in great numbers nor of much importance. The latter is due to the presence of many other more valuable timber trees, and to the fact that the timber of New South Wales Obliqua is not nearly equal in quality to that of Victorian grown trees, and still less so to that of Tasmanian grown.

Size and Form.—Stringybark is one of the great trees of Tasmania and Australia, especially so of the former country. It attains to a height of 250 feet and a diameter of 14 feet or over in Tasmania, but its more usual dimensions are from 150 to 200 feet height, and 6 to 8 feet diameter.

The better type of Stringybark is an exceedingly fine central stemmed tree with a very straight clean bole reaching to a great height. The whole of the trunk and the larger

limbs are covered with a fibrous, matted, stringybark. The extension of the stringybark right up the trunk and along the larger limbs is the most conspicuous distinguishing feature as opposed to the appearance of the Gigantea and other Stringybarks. The leaves are also a distinguishing feature, being large, very broad, and markedly oblique.

Some local variations of the Stringybark seem to have a bad tendency to being many stemmed or very branchy. Such should be shunned as a source of seed supply.

Rate of Growth.—The Stringybark is a very rapid growing tree. It is, where conditions favour it, amongst the first few most rapid growing Eucalypts.

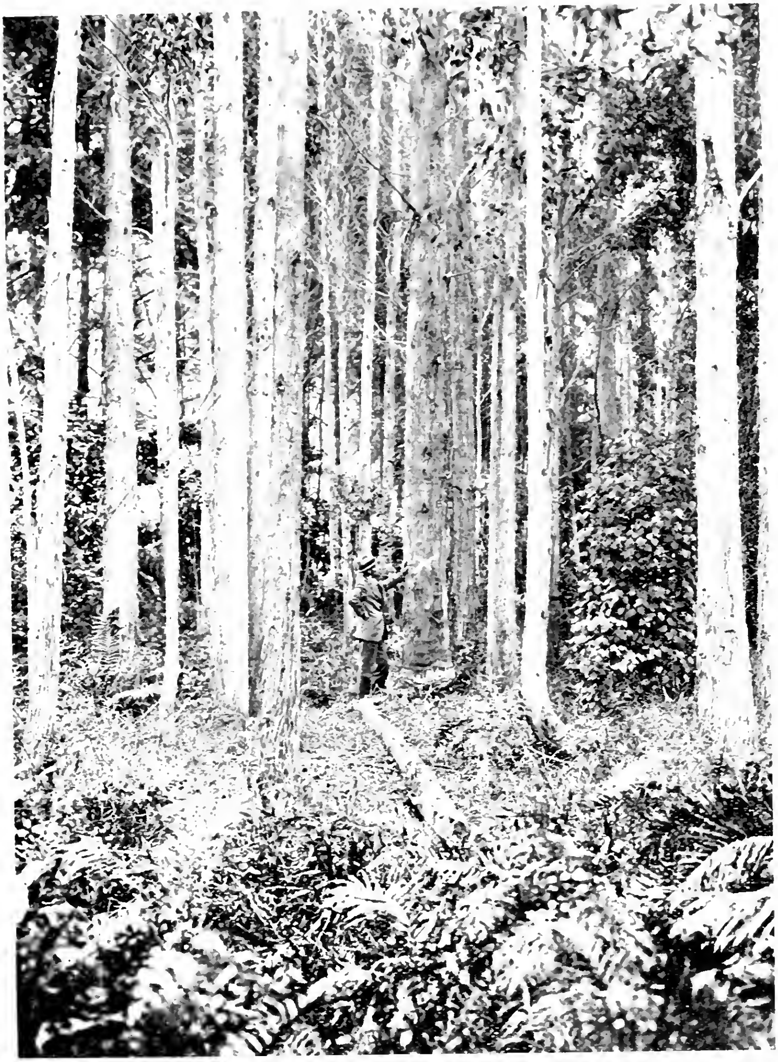
In the plantation of the writer it grew to the height of 80 feet and a diameter of 16 inches in sixteen years. An independent tree had reached in that time a diameter of 21 inches 4 feet from the ground.

Timber.—The timber of the Stringybark grown within or near the species' optimum of climatic and soil conditions, is very fine and valuable. It is strong, tough, straight grained, very fissile, dresses well, and is a handsome wood which varies in appearance from that of Oak to that of Ash. It weighs 46 lbs. to the cubic foot and is serviceable for a very great range of purposes. In Tasmania it has proved a most valuable and very durable timber, lasting for a great number of years in marine works, bridges, and other purposes where exposed, also as ordinary building timber, coachbuilders' purposes, furniture, etc. It was largely used and exported for shingles, palings, fence rails, etc., being the timber from which in earlier days the very well-known Hobart shingles, palings, and rails were split. It has proved Tasmania's most valuable timber.

In Victoria also it is considered a timber of considerable value for very many purposes, and is very widely used, but it has not exhibited the same degree of durability as in Tasmania.

In New Zealand, where properly grown from Tasmanian seed, the indications are that it will prove a producer of timber of high quality and durability.

Climate and Soil.—The Stringybark is a distinctly hardy tree. At times the seedlings or quite young plants are touched by frost. Such have probably been raised from New South Wales seed. It is hardier than the Blue Gum (*E. globulus*) and thrives under a wider range of conditions. Stringybark



A Taranaki plantation of *Eucalyptus obliqua* (Stringybark) 15 to 17 years old, 70 to 80 feet high. Originally planted, in alternate rows with wattle, two feet apart, from which poles are removed from time to time.

and Fastigata are probably, of all the Eucalypts, the least demanding as to conditions so long as the climatic conditions are not both too hot and dry, but both thrive best in soil of fair quality, deep, porous, and moist, and where the climate is mild and moist. In Tasmania is the optimum of the natural habitat of the species, and therefore it is there that the timber would be of the highest quality, whilst New South Wales is the most remote from the optimum, and there the timber would be, and is, of lower quality.

The climatic and soil conditions in many parts of New Zealand are similar to the optimum of its natural habitat, and from that and the experience already gained as to its growth in New Zealand it should, if grown from seed collected from best type trees in Tasmania, and grown in proper density, prove a very valuable tree for afforestation purposes.

It has been grown, and should do well, in parts of South Africa, where there is a fair rainfall and the atmospheric and soil conditions are fairly moist. But it would seem that seed from a rather poor type—probably from New South Wales—has been introduced into South Africa. Good selected Tasmanian seed should be obtained.

In parts of New Zealand exceedingly poor type many stemmed, much branched or short boled trees are to be seen, and as the Stringybark is a free seeder and ready grower, and only from such trees can seed be easily obtained, this poor type tree is being widely spread.

Reference has already been made to experience of the writer in connection with good and bad Stringybark seed. The writer collected seed from best type straight central stemmed trees with the result that the plantation grown from that seed turned out practically 100% perfect straight stemmed trees without limbs of any size, just small branches at the top of long clean boles, 70 to 80 ft. x 1 ft. 6 in. in 16 years. On the other hand a plantation was put in, in a more favoured situation, with plants grown from bought seed. This plantation proved 100% failure, not one tree that did not grow with short stems heavily limbed.

Sylvicultural, etc.—The germination of Obliqua seed is distinctly low, and consequently a much greater supply is necessary for a given number of plants in proportion to most other species. The seedlings do not start away in growth as readily as many others, and are rather large leaved, consequently require room. If grown in good free soil and properly

wrenched the seedlings transplant well enough, but are rather sensitive, especially to dryness.

The Stringybark, if given much room, gains diameter growth too rapidly, with result the timber is coarse grained and weak in proportion to its bulk. It should be planted densely, better rather over densely than otherwise, but the plants should be strong, well graded, even quality and size, and carefully planted, otherwise the growth will be uneven, followed by much natural suppression, which will defeat the object of dense planting. Of course the dense planting must be followed by periodical thinning.

Mixed planting with other Eucalypts, of equal growth in the situation, or with Insignis may be adopted with advantage, the latter, provided that not only the situation is favourable to the growth of the Stringybark, but that the actual condition of the soil favours the Stringybark making quick early growth. If planted pure, unless clear cut at a comparatively early age, underplanting with the most rapid growing pine should be undertaken when the amount of thinning reaches a stage when the forest floor becomes too open. Ample rainfall or generous soil and atmospheric moisture is necessary when underplanting Eucalypts with pines.

Eucalyptus oreades (syn. *E. Luehmanniana*, var. *altior*).

Oreades does not seem to have any vernacular name, which is doubtless owing to it being very little known, and practically not at all used for timber purposes.

It has what is probably the most restricted range of any of the Eucalypts, being confined to the Blue Mountains in New South Wales, where it is found in the valleys of the higher parts, and is with its tall conspicuously white bare stems a distinct feature.

It is a distinctly hardy species, seems not at all sensitive to a change of home, and promises to be a valuable tree for afforestation purposes.

Size and Form.—In its natural habitat it is a fair sized tree, but does not attain what would, compared with many of the Eucalypts, be considered large dimensions.

The juvenile form of leaf, and the colour of twigs and foliage is very suggestive of Gigantea, but the leaves are somewhat narrower, and though in some other respects, including the timber, there seems to be an affinity to Gigantea, the trees

are easily distinguishable. Oreades is a somewhat slim straight clean stemmed tree, with smooth whitish bark, the dead bark coming away in long strips.

Rate of Growth.—There do not seem to be any Australian records as to rate of its growth, but in New Zealand it has made rapid growth. The Rev. J. H. Simmonds records a growth of 100 feet height by 2 feet diameter in 30 years at Tarukenga, near Rotorua.

Timber.—The timber of Oreades is strong, tough, straight grained, fairly hard, splits easily, and bends well. It is very similar to that of Gigantea, and nearly as good, and suitable for most of the same purposes. It is heavier, being 46 lbs. per cubic foot. Its durability does not yet seem to be known.

Climate and Soil.—Though it is restricted in its natural habitat to the valleys of the higher parts of the Blue Mountains, it seems to adapt itself to varied conditions, but cool and moist atmospheric and soil conditions suit it best. For afforestation purposes its place is in the higher country in the warmer climes, but in New Zealand it thrives inland where the winters are cold, and in semi-coastal locations where there is a good rainfall. Any free, porous soil suits it well. There is no evidence as to how it will do in stiff clay or shallow soils with hard subsoil.

Sylvicultural, etc.—In all particulars similar to Gigantea.

General.—Though it is distinctly a hardy and rapid growing tree, the timber of which has many good qualities and useful for many purposes, its degree of durability does not seem to be known. Therefore, unless its rate of growth is distinctly greater than that of Gigantea, the latter should be generally preferred to Oreades for any extensive use for afforestation wherever conditions suit the Gigantea.

It may be that when more is known about Oreades it may prove entitled to greater consideration.

Eucalyptus Sieberiana ("Towut" or "Mountain Ash.")

Sieberiana is one of the several "Mountain Ashes." It is known in Tasmania and in Victoria by several other names, such as "Gum-topped Stringybark," "White-topped Ironbark," "Messmate," and "Stringybark." It belongs to Tasmania and Victoria, and also occurs in the Snowy Mountains in New South Wales. Its natural habitat is in the mountains at

considerable elevations, though descending to lower positions in parts of Victoria and Tasmania.

It is a distinctly hardy and rapid growing tree, suitable for afforestation.

Size and Form.—Sieberiana is a medium sized tree reaching a height of 100 feet and rarely 120 feet, and a diameter in extreme up to 4 feet, but usually a tree of 70 to 80 feet height, 1 foot 6 inches to 2 feet in diameter. It grows with a stem quite clear of branches for the greater part of the height of the tree, but the stem is rarely quite straight.

Rate of Growth.—It is a fairly rapid grower. In the plantation of the writer it reached a height of about 65 feet and a diameter of over a foot in 16 years.

Timber.—The timber is fairly strong, tough, hard, and durable, is easily split. It is a valuable timber of general utility, and is an excellent fuel. There are very conflicting reports as to its durability, but the weight of evidence is in favour of durability. Richard T. Baker, in his *Hardwoods of Australia and their Economics*, gives the following description: —"It is a first-class timber for general building purposes, bridge work, wharves, and heavy coach and carriage work."

Climate and Soil.—It is a hardy tree, standing a considerable amount of frost, and is at home in high elevations, but grows well at lower levels in semi-coastal and inland areas in New Zealand.

Though doubtless it makes the best and most rapid growth in good soil, it will thrive better than most of the Eucalypts and thrive well in poor hard, stony or rocky, and even almost barren situations, and for these reasons has a distinct place in afforestation of areas that are unsuited for many species of Eucalypts.

Sylvicultural, etc.—It is a free seeder, and the seed germinates well. Rather more care is required in transplanting the seedlings than is necessary with those of some species.

Fairly dense planting is necessary to obtain good results. The young plants get away from the weeds fairly well. Sieberiana will thrive in mixture, and requires much the same treatment as others already dealt with, except that it is more likely to be outstripped in the course of time if planted with species that will continue growing rapidly to heights exceeding say 80 feet.

Eucalyptus Blaxlandi (Blaxland's Stringybark).

This Stringybark is not very well known yet, and there is little information available as to its qualities.

It is confined to somewhat restricted limits and to New South Wales. The Blue Mountains are its chief habitat.

Reference is made to this Stringybark here because it is a hardy tree, and apparently a fast grower. It is easily raised, transplants well, and makes a good early start, getting away from the weeds quickly.

Though it would be unwise to plant it extensively until more is known about it, experimental plantings should be made in situations such as are likely to suit it.

Climatic and Soil Conditions.—Somewhat similar to the requirements of Oreades should suit it.

It has been planted experimentally at the Taranaki Forests plantation, and is giving promise of success.

It grows to a height of 150 feet and a diameter of about 4 feet.

Chapter LXII.

CLASS 2—FAIRLY FROST HARDY EUCALYPTS (Contd.)

Eucalyptus regnans ("Giant Gum").

The Giant Gum is also known in Victoria as "Mountain Ash," in New South Wales as Blackbutt, in some districts even as "White Gum" and "Cut-tail," but "Giant Gum" is the only distinctive name, as all the others are also, and most commonly, applied to other species.

It is well worthy of the name "Giant Gum" for it is not only the largest of all the Eucalypts, and as such the largest tree in Australia, but it is one of quite the largest trees in the world.

It is confined to Victoria, New South Wales, and Tasmania, and although it is found growing practically at sea level its most natural habitat is in the mountains up to elevations of well over 3,000 or perhaps 3,500 feet.

Size and Form.—The Giant Gum's exact relative size amongst the greatest trees in the world is not known, but it is cer-

tainly within the first four. There are quite definite records of trees up to 326 feet in height and of nearly 20 feet diameter. Much greater dimensions have been claimed for it, but not substantiated. However, as numberless great trees had been destroyed before any exact measurements were taken, it is more than probable much larger trees than those actually measured have existed.

The Giant Gum is, as the measurements indicate, a magnificent tree. It has a very straight bole reaching to a great height before being lost in limbs. The bark of the typical Victorian tree is, except at the butt, quite smooth and whitish or grey-green, the old bark coming off in long thin strips.

Timber—The timber of the Giant Gum cannot rightly be claimed as a high class timber, but for all that it is a timber of fairly wide utility within limits where neither much strength nor durability is required. Its uses are more for purposes where a softwood would ordinarily be used than where a hardwood is required. The timber is very light in weight, being little over 40 lbs. to the cubic foot. That of well-grown trees is exceptionally straight in the grain, very easily split and worked. It is pale in colour, in grain suggestive of European Ash, and is somewhat similar to, and answers for several of the purposes as that of Gigantea and Obliqua, but is an inferior timber to either of those. Only the timber of matured trees should be used, except for case and pulp wood, as that of young trees is markedly of even less quality.

The timber, as would be expected considering the great quantities of it that have been available, is very much used, and if from matured trees, cut at the right time, well seasoned, and not used where unprotected, would be a serviceable timber for many purposes.

But it is the opinion of the writer that there is no warrant for using the Giant Gum for the purposes of afforestation unless it is intended to grow the timber to use in place of low quality softwood. The reasons for this opinion are (1) In plantations only a short rotation would be adopted, the period of which would be so remote from the maturity age that the timber, as before indicated, would be of very low quality, and (2) rapid growing species that produce much better quality of timber, even when comparatively young, thrive well in the same situations as the Giant Gum requires.

Rate of Growth.—The Giant Gum is a very rapid grower in early youth, but not so fast later on. However, on the whole

it is a rapid grower, and it has the desirable quality of outstripping weed or other growth, which tends to an even, fully stocked stand.

Soil and Climate.—It is fairly frost resisting and hardy, but not suitable for exposed positions, especially such as would be subject to strong sea winds. It is quite unsuited to very hot and dry conditions, and requires a good rainfall, plenty of moisture, and fair quality of soil to do well.

It thrives well as far south as Otago, and has been planted and does well in many other parts of New Zealand.

Sylviculture, etc.—Giant Gum is very easy to raise and transplant. It will grow very densely, and should on no account be over widely spaced. If planted in "pure" stand and thinned it should be underplanted. It does well in mixture with Insignis and Wattles. As it is a distinctly rapid grower in youth and a rather heavy foliaged tree, it can be satisfactorily used for interplanting pines that have had a year or two start.

Close planting with Insignis alone in excess number to the Insignis is likely to result, in situations favourable to the Giant Gum, in suppression of the Insignis.

Eucalyptus viminalis (Manna Gum or White Gum).

The Manna Gum has a wide distribution throughout much, especially the cooler parts, of southern (but not in western) Australia and Tasmania.

It certainly does not rank among the higher class gums, and has no particular reputation in its natural home, but in New Zealand, owing to its adaptability to a wide range of New Zealand conditions it has become a species of distinct repute.

Size and Form.—The Manna Gum, so called because of the sugary substance exuded by the leaves, is a very handsome, or it may be said, beautiful tree. Its narrow wide-spread drooping foliage and great gleaming white boles and gleaming white to palish green branches, make it remarkable and very attractive.

It is one of the great trees, ordinarily reaching from 130 to 150 feet in height by 6 to 8 feet in diameter, but in specially favourable situations the height mentioned is much exceeded, and much greater diameters have been recorded. The boles

are usually straight or fairly so, but it has a tendency towards putting out heavy limbs.

Rate of Growth.—In situations that suit it and if not injured by insects the Manna Gum is a rapid grower.

Timber.—The timber is not of high quality, and is not in good repute as to strength or durability in Australia, nor as to the way it seasons. In fact it is generally, in Australia, looked upon as an inferior timber, lacking most desirable qualities, and subject to attack by insects and dry-rot, and with a tendency to warp and twist. Notwithstanding the foregoing, it is used as a building timber to some extent. In New Zealand the timber of densely grown trees thirty to forty years old is supposed to have a fair degree of durability for fencing.

Climate and Soil.—The Manna Gum is a hardy tree, and stands a considerable degree of frost. It will grow in comparatively poor soil and under a variety of conditions, but it distinctly prefers cool and moist conditions. It thrives best in deep fertile soil where there is plenty of moisture—a fairly high rainfall as well as soil moisture. It is not suited to coastal situations.

Seedlings are very easily raised and transplant well.

On account of the poor quality of the timber and that the species requires conditions under which much more desirable species will thrive, and also as its foliage is very liable to attack by insects to such an extent as to frequently seriously retard or even entirely destroy its growth, there does not seem to be any warrant for its use in afforestation, and it is only dealt with here because it has been so widely planted in New Zealand that it is desirable to draw attention to its disadvantages. It may be that, in some of the colder parts, this species may have proved its superior suitability to particular situations whilst other species supposedly suitable do not thrive, in which case there would be warrant for planting it in such places on account of its rate of growth and size, notwithstanding the poor quality of its timber, which might be treated with preservative.

Eucalyptus amygdalinus, Tas. var. (Tasmanian Black Peppermint).

There are several variations of Amygdalinus spread over New South Wales, Victoria, and Tasmania. The Tasmanian variety is the more valuable tree. With its pale grey or almost

white stems and limbs, and the narrow, dense, slightly drooping foliage, it is a very beautiful and graceful tree. By some it is thought to be the most beautiful of all the Eucalypts. Right from almost the seedling stage it has a peculiarly attractive graceful appearance. It is a fairly good frost resister, and in every way is a hardy tree.

Size and Form.—It is usually a tree of 60 to 70 feet height with a diameter of 2 to 3 feet, but in favourable situations it attains considerably greater dimensions. A 25 year old tree in the writer's plantation, which had its stem broken about 15 feet from the ground when about 10 years old, is now about 70 feet high with a diameter of 2 feet 6 inches 4 feet from the ground. From where it was broken there are three fairly erect stems 1 ft. 3 in., 1 ft. 2 in., and 1 ft. diameter. Though a fairly central stemmed tree it is seldom quite straight, in fact is usually rather irregular.

Rate of Growth.—The Black Peppermint, though rather slow at starting, especially where the soil does not suit it well, is afterwards a rapid grower, though not amongst the first rank of rapid growers. Trees taking 15 years to reach a height of about 45 to 50 feet, with a diameter of 12 to 14 inches, would fairly represent usual rate of growth.

Timber.—The timber of the Tasmanian Black Peppermint is strong, dense, and very durable, even that of young trees lasts well as posts. The durability of the Black Peppermint is in marked contrast to that of the mainland varieties, and is quite the chief recommendation for the tree for anything other than ornamental purposes. It provides a very good fuel.

Climate and Soil.—The Black Peppermint is a distinctly hardy tree, and will thrive under a fair range of climatic and soil conditions. It does not like extreme heat or extreme dryness, but will stand drier conditions than many. At the same time it thrives best where there is a good rainfall and fairly moist, but not too wet, soil. It grows well in poor and even hard soils, but is better suited with deep and fairly porous soils.

Sylvicultural, etc.—The Black Peppermint is a very free seeder, even at a comparatively young age. The seed grows freely, but it seems rather difficult to raise sturdy well-shaped seedlings, and the percentage of failures in transplants is frequently rather high. Further, the transplants are rather slow in getting away from the risk of suppression by weeds

and other dangers. The foliage of young plants and young seedlings suffers much at times from attacks of green beetles.

Black Peppermint grown in "pure stand" exhibits its tendency to rather irregular stem growth, and the writer is not aware of any sylvicultural treatment that will overcome this tendency, which constitutes a distinct drawback to it as a tree for afforestation purposes, at least for extensive afforestation. It would be a less serious fault in the woodlot, from where it would supply valuable fencing and fuel.

The writer has grown Black Peppermint on a small scale mixed with Acacia mollis—Black Wattle—where the conditions were favourable to vigorous growth of the Black Peppermint, but though the spacing of the mixed planting was 4 ft. x 4 ft. in the first instance, the Black Peppermint still exhibited its irregular habit of growth.

The decided durabilty of its timber, its hardiness, and the fact of its being less sensitive to climate and soil conditions, may, notwithstanding its irregular growth, warrant its use in small plantations, especially in such as the material from which will mostly be for local use in poles, fencing, and fuel.

Eucalyptus Smithii ("White Top" or Gully Ash).

Smithii is comparatively little known, and has only come into notice in recent years. Doubtless this is due to its very limited range, which is restricted to a few localities in south-eastern New South Wales, and so far is noted in only one or two places in Victoria. It, like Oreades and Blaxlandi, is a mountain species, growing in valleys at from 1,000 to 3,000 feet elevation, and consequently it is a fairly hardy species.

Size and Form.—Smithii grows, in extreme, to a height of 150 feet and a diameter of up to 5 feet, but it is usually a smaller tree. It resembles the Viminalis both in juvenile and mature foliage, but does not do so, either in form of the tree, nature or colour of bark.

In some situations it is a tall, clean straight stemmed tree, but in others it is somewhat branchy. The bark is rough on the lower part of the stem and smooth higher up, dark in colour.

Rate of Growth.—Rapid when young, but there is a lack of data as to the rate later on, though the indications are that it is a fairly fast growing species.

Timber.—The timber is hard, strong, close grained, tough, and fairly heavy, weighing 60 lbs. to the cubic foot. Accounts

as to its durability are rather contradictory, some noting it as "durable," others as "fairly durable," and others as "good durable timber," whilst by others no reference is made as to durability. Rather inclined to shrink when seasoning. Suitable for general building purposes, bridge superstructures, and such like, fence rails, and palings.

Climate, Soil and Treatment.—Smithii has been very little planted, and that little only of late years, and therefore little is known of its requirements, which can only be judged by the conditions of its natural habitat, viz., that of mountain valleys at considerable elevation, where the conditions are cool and moist. It is easily raised and transplanted, and makes a fairly rapid start in growth. The indications are that it may prove a suitable tree for afforestation purposes in some situations, but it would seem unwise to plant it extensively at present, pending further knowledge of it, except in any position in which it thrives well, and in which other more valuable species do not.

Chapter LXIII.

CLASS 3—SLIGHTLY FROST HARDY EUCALYPTS.

Eucalyptus Bosistoana ("Bosisto's Box" or "Red Box").

Red Box seems to be confined to eastern New South Wales and part of Gippsland. It is one of the larger, finer, and valuable trees of Australia, and probably the most valuable of those of Victoria. Although it has been little grown up to the present it is likely to prove an exceedingly valuable tree for afforestation in certain situations.

Size and Form.—Red Box attains in specially favourable situations to a height of as much as 250 feet, and over 10 feet in diameter, but it more commonly is a tree of from 150 to 200 feet in height and 3 to 6 feet diameter.

It has a straight long stem clear of branches, with a symmetrical head.

Rate of Growth.—Though there is a lack of data as to its rate of growth later in life, it has proved to be a fairly rapid grower when young, both as seedling plants and as saplings.

Timber.—Red Box timber is of high quality and very valuable, and it is considered by some to be equal to that of the best Ironbarks, and is obtainable in larger sizes. It is tough, extremely hard, dense, very strong, and very durable. Its weight is 69 lbs. to the cubic foot. It is of service for all the purposes that the Ironbarks are—piles, wharves, bridges, beams, stringers, sleepers, posts, poles, wheelwright's purposes, etc.

Climate and Soil.—Its exact place as to degree of hardiness is not at present easy to fix, but as it is found at elevations up to 3,000 feet in Australia, and as it grows in the Wairarapa (N.Z.), where frosts are fairly severe, and also is growing in a semi-coastal location in Taranaki, it is placed among the slight frost resisters.

Whilst the Red Box does well on stony and limestone highlands, it prefers good quality deep friable moist soils, with a cool climate and good rainfall.

It is suitable for afforestation purposes in many parts of our southern lands where the climatic and soil conditions are moderate, neither extremely cold, hot nor dry, nor the soil too wet or too dry.

It thrives wonderfully in fairly sheltered cool moist situations, the young plants getting rapidly ahead of the weeds, which is a most important quality in species used for afforestation purposes.

Sylvicultural, etc.—So little is known of the Red Box and it has been so little planted that there is no guide as to any special treatment that might be desirable, therefore until more is known the course open is to treat it much in the same way as most of the other species. This lack of precise knowledge should not deter considerable planting of this species in situations favourable to it, for the strength and durability and other good qualities of its timber, combined with its rapid growth, anyway during early years, and the larger size that it attains indicate that there is every prospect of it being one of the most valuable species for afforestation.

Eucalyptus botryoides ("Bangalay," "Bastard Mahogany," or "Swamp Mahogany").

Bangalay is a native of New South Wales and Gippsland. It belongs to a group of Eucalypts of which Robusta may be taken as the type—some of the others are Saligna and Resini-

fera—which have somewhat heavy leaves with a distinct midrib and practically equal sides, and they are lateral not vertical as is the case with those of so many species of Eucalypts.

The Bangalay is closely allied to the Sydney Blue Gum (*E. saligna*), the latter being an inland type and the former a coastal.

Size and Form.—When growing independently it is a heavy not very regular or straight stemmed, much branched and heavy dense foliaged tree, but when grown under proper forest conditions it will reach a height of 150 feet—some with a diameter of 6 to 7 feet—with a perfectly straight clean bole without a limb for 60 to 70 feet or more, and altogether a very fine tree.

Rate of Growth.—In New Zealand it has proved an exceedingly rapid grower, at least so during earlier years whatever it may become in later life. Six year old trees in the plantation (Cape Egmont district, Taranaki) of the writer have reached as much as 50 feet height and 6 inches diameter, and at the plantations (near New Plymouth) of the Taranaki Forests a height of 25 feet and 4 inches diameter has been reached in just under three years.

A most astounding rate of growth was noted for this species in India, but a doubt was raised as to whether it was not a hybrid.

Timber.—The Bangalay timber is exceedingly valuable. It is strong, tough, hard, close-grained, heavy (66 lbs. to the cubic foot), and very durable. It is regarded as among the best of Eucalypt timbers, and Richard T. Baker, in his work *Hardwoods of Australia and their Economics*, records it as being "suitable for all heavy constructional works, carriage and house building, sleepers, frames for punts or lighters." It is one of the four Australian timbers recommended by the Victorian Carriage Timber Board for use in the construction of railway carriages.

Climate and Soil.—The Bangalay is a very much hardier tree than would be supposed judging by its natural habitat, which is chiefly coastal areas in New South Wales and Gippsland. Although there is a small mountain variety, the type is distinctly a lowland tree. The soil conditions most favourable to its most vigorous growth are deep rich moist friable sandy loams in valley bottoms and along river banks. It is a distinct moisture lover, and thrives surprisingly in drained but rather

wet swamp lands. One of its vernacular names is "Swamp Mahogany."

The Bangalay is thriving well in New Zealand in semi-coastal regions where there is a good rainfall, and in the interior—Waikato and Rotorua—where there are considerable frosts. The Bangalay will grow in poor sandy soil, but the trees are smaller and the timber inferior.

Sylvicultural, etc.—The Bangalay is very easily raised, very easily transplanted, and is an exceedingly rapid grower as seedlings in the nursery, and as transplants getting above the weeds very quickly. It is a broad-leaved heavy foliaged tree, and a distinct light demander, consequently less density in planting or then early thinning is necessary. Greater care is called for and less freedom of choice in composition of mixtures in which Bangalay forms part. It will, though growing rapidly just at first, soon suffer severely from over shading. Fastigata, for instance, where the conditions are favourable to it, and it is one of quite the least particular, will very soon dominate the Bangalay.

Bangalay will thrive well in many parts of most of our southern lands, and is certainly one of the most valuable trees for afforestation purposes.

Considering its rapid hardy growth, and the qualities of its timber, it is surprising that it has not been more planted.

Eucalyptus saligna and var. pallidivalvis (N.S. Wales Blue Gum—Flooded Gum).

Saligna and the variety are both confined to New South Wales and southern Queensland. They are both exceedingly valuable trees for afforestation purposes, and so far little, if any, distinction has been made between the two varieties in their use for afforestation. In fact it has been little recognized that there is any variation, consequently there is, so far, no information available as to which variety is the better for such purposes, nor what climatic and soil conditions favour one more than the other, but it is most important that precise knowledge should be obtained as soon as possible as to their comparative rates of growth and climatic and soil requirements, as according to Richard T. Baker in his *Australian Hardwoods and their Economics*, var. pallidivalvis produces a considerably stronger and a heavier timber than the type.

Saligna has been known by both names—New South Wales Blue Gum and Flooded Gum, because of the confusion between the two varieties, but when var. pallidivalvis is distinguished, "Flooded Gum" is the name applied to it.

J. H. Maiden, in his work *The Forest Flora of New South Wales*, mentions a variety "parviflora," known variously as "Silky," "White," "Blue," "Brown Flooded," and "Round-leaved Blue" Gum. It is described as a larger tree than Saligna proper, but the timber is indicated as inferior.

Planters are, failing collection of seed from trees the type and special variety of which are assured, at the great disadvantage of never knowing what will result from the seed sown. There is not only the confusion of the different varieties of Saligna, but there is that between Saligna and Botryoides which species are very nearly allied. Very seldom, if ever, is bought seed of Saligna unmixed with that of Botryoides and *vice versâ*.

Saligna is one of the group of distinctly mid-ribbed, equal sided, lateral leaved Eucalypts, and in some stages it very much resembles its near ally Botryoides. When in the sapling stage the bark of the latter is brown and somewhat rough right up the stem, whilst that of Saligna is quite similar for a time for 5 to 7 feet up the stem, but above, and later on below as well, is very smooth grey-green. Later in life the bark of Saligna is a bluish-white, very smooth, and is almost metallic-like except at the base of the trunk, where it is somewhat fibrous. The bark of the grown tree, of Botryoides is fibrous, furrowed, rough and dark in colour, but there is a considerable variation from tree to tree as to how far up the stem, or on to the branches, this bark is persistent.

Size and Form.—In both varieties Saligna is an exceedingly handsome, striking tree, reaching a height of 150 feet or over, and a diameter of 7 or 8 feet. It has a very fine symmetrical bole somewhat spread and buttressed at the base, as is the tendency of trees which grow in swampy or deep moist situations.

Rate of Growth.—The Saligna is an exceedingly rapid growing tree, one of the most rapid growing. In some situations it would seem that it exceeds in rate that of Botryoides, but usually it is not so rapid as its ally. It has shown great rapidity of growth in many countries other than its native one, among others New Zealand, South Africa, India, and South America.

A heavy summer rainfall in parts of South Africa seems to have suited it well. Both in Western Cape Province and in the Transvaal it has grown excellently, and has in parts outstripped all other Eucalypts in rate of growth. In the Transkei 15 year old trees have reached 80 feet in height.

In Southern Rhodesia it has not only done well, but is making such phenomenal growth that it would seem likely to exceed that of any species anywhere, reckoned on an acreage basis of annual increment over a period of about 20 years.

In New Zealand it has thriven surprisingly in many parts of the North Island, both in semi-coastland and inland positions, for instance in the Rangitikei district, where frosts are fairly severe, in Taranaki, in the Waikato, and even in more favoured situations at Rotorua.

In the plantation of the writer, Cape Egmont district, 7 year old trees are 45 ft. in height and 5 ft. to 6 ft. in diameter, running closely with Botryoides for second place after Fastigata. Just which variety, Saligna or var. pallidivalvis, is the more rapid grower has yet to be settled.

Timber.—J. H. Maiden records it as "one of the best hardwoods of the State," and it has to be remembered that New South Wales is the home of the strongest, hardest, and most durable timbers, to fully appreciate what this implies. Richard T. Baker describes it as "one of our finest hard redwoods, being of medium weight (46 lb. per cubic foot), easy to work, durable, dresses well, and in general demand throughout the timber trades." He gives the weight of var. pallidivalvis as 50 lbs. per cubic foot, and the strength as very considerably exceeding that of Saligna proper.

It is difficult to judge accurately from the many reports as to durability, as in many there is obvious confusion between the different varieties. The timbers of both are undoubtedly durable, but there would seem to be indications that that of the Pallidivalvis is more so. The timber has a very wide range of utility, for, in addition to being hard, strong, and durable, it is very light in weight compared to the Ironbarks and many other hard strong and durable timbers, and being a very handsome timber is suitable for furnishings, panelling, etc.

Climate and Soil.—In the matter of hardiness there is a peculiar variation that doubtless is accounted for by the seed coming from different localities and also from different varie-

ties. Saligna is confined to New South Wales and Southern Queensland, and it does not extend as far south as its ally Botryoides. Further, Saligna may be considered a forest form whilst Botryoides is a more open grown form. Botryoides planted in some districts proves a hardier tree than Saligna, whilst in other the latter seems to withstand severer conditions than the former. However, they are both fairly hardy, but neither is suitable for a severe climate. Both are great lovers of moisture, and require deep fertile porous moist soils, and considerable atmospheric moisture to make their best growth, though they will thrive in less fertile and less porous soils. In South Africa Saligna thrives where there is a heavy summer rainfall. Both species thrive surprisingly in drained swamp land where there continues a generous supply of moisture, and also in well sheltered alluvial flats and valleys, but will do fairly well in more exposed situations. But in such situations as good results cannot be looked for.

Sylvicultural, etc.—The same applies to Saligna as to Botryoides except that Saligna, though distinctly light demanding, stands more shade than Botryoides does.

Saligna is an exceedingly valuable tree for afforestation purposes, both on account of its very rapid growth and the high quality of its timber.

Eucalyptus pilularis ("Blackbutt").

The Blackbutt ranks high among the giant Eucalypts, and it is certainly a most noble tree, quite distinct in appearance from most of the Eucalypts. It gets its name "Blackbutt" from the very dark somewhat stringy sort of bark with which the butt of the tree is clothed. The butt swells greatly into somewhat broad buttresses, which in many cases continue up the trunk for a considerable distance in the form of irregular wide longitudinal corrugations. The trunk, though in the main a very fine bole, is frequently superficially rather rough or somewhat gnarled looking.

The Blackbutt, as far as recorded, is confined to New South Wales and Queensland, and a small part of Victoria. Its width of range is from the coast to about 100 miles inland up the slopes of the Dividing Range on to the Tableland.

Size.—As stated, it is one of the giant Eucalypts. It reaches a height up to 300 feet and a diameter of over 15 feet. To quote from J. H. Maiden's *New South Wales Forest Flora*, "A

tree at Bulli was measured by me in 1891, with the following results:—Girth at ground, measuring from buttress to buttress, 57 ft. 6 in.; the girth 3 ft. from the ground was 45 ft.; and at 6 ft. from the ground 40 ft. The taper was then very gradual for 90 feet (estimated), where the head was broken off. There are ten principal buttresses of an average diameter of over 2 feet, but they practically cease to flute the trunk at a height of 10 to 15 feet." The fluting, in many cases, ascends the tree much higher than in the above case.

When grown independently or amongst low-growing trees, the Blackbutt is frequently a much-branched tree with a comparatively short trunk, but when growing in the forest along with other tall growing trees it has a very long bole quite clear of limbs.

Rate of Growth.—Blackbutt is a fairly quick grower, quite quick enough, considering its other qualities, to make it a distinctly desirable tree for afforestation purposes in situations that favour it. It has already reached millable size in places in New Zealand.

Young trees if planted in favourable situations make rapid growth. At the plantations of the Taranaki Forests Blackbutt, grown from the transplants not direct from seed, has reached 14 feet in just under three years.

Timber.—Blackbutt timber is an exceedingly valuable timber, about the same strength as that of Saligna, var. pallidivalvis, but about 18% heavier. It ranks among the best timbers, is hard, strong, straight-grained—sometimes less so—and exceedingly durable. J. H. Maiden ranked it with Saligna, Tallowwood, and Resinifera as the most valuable timbers after the Ironbarks. It has a wide range of uses, including that of general constructional work, building, planking, ship work, wood blocks, poles, piles, posts, railway sleepers, etc.

Its chief quality is its great durability. Lintels above a doorway in the old Sydney Law Courts were removed after being in position over 100 years, were examined by experts, and proved to be Blackbutt and Red Mahogany (*E. resinifera*), and were found to be perfectly sound, free from dry-rot or decay of any description.

Climate and Soil.—Doubtless the degree of hardiness of Blackbutt will much depend upon where the seed is collected. If from lowland Queensland situations near the coast the young trees will be very much more sensitive to frost than if raised

from seed collected from trees growing at fair elevations, mountain or table-land, somewhat inland in New South Wales. If the seed is procured from such localities Blackbutt may be classed as "Slightly Frost Hardy." It has grown well in many places in the North Island of New Zealand, and in Nelson (S.I.) it has attained large size. Seedlings have been raised without any cover, successfully transplanted, and grown to a height of 14 feet, south of New Plymouth at, as already mentioned, the plantations of the Taranaki Forests, in just under 3 years, without being affected by frost.

To thrive well the Blackbutt requires good rich, or fairly rich, deep, friable, loamy soil, with fair moisture, and fairly moist atmosphere. The better the soil conditions and the more sheltered, the less rain is necessary. There is no use attempting to grow Blackbutt in poor, or cold, or hard soils, or in bleak situations. Under congenial climatic and soil conditions Blackbutt will thrive well and make rapid growth.

As the quality of its timber so nearly approaches that of the Ironbarks, the rapid growth of the Blackbutt—which in rate exceeds that of any Ironbark, the nearest in rate of growth of any of which is that of the "Grey Ironbark" (*E. paniculata*)—is most important, and foresters should give it full consideration, not allowing the fact that the Blackbutt requires good land to unduly discount the great advantage of quick growth of such a valuable timber producer.

Sylvicultural, etc.—The amount of information available as to the sylvicultural treatment best suited to Blackbutt is very limited. It is a very free self regenerator, where a Blackbutt stand has been either clear cut or heavily opened through removal of the larger trees. The seed germinates well, and the seedlings are easily raised. Some people consider the seedlings hard to transplant, but the experience of the writer does not indicate that they are so. If the seedlings are sturdy—raised in narrow lines and unprotected, and well wrenched there should be no difficulty if treated properly and well planted, in obtaining a high percentage "take." If the soil is good and has been cultivated the young plants will grow rapidly, and should get well beyond the weeds with one cleaning, after which they will make rapid growth.

Indications are that Blackbutt should not be overcrowded, though it will stand a fair amount of shade—that is for a Eucalypt. But on the other hand if over widely spaced it will probably branch badly. If mixed with other species of the

Eucalypts in the first instance possibly the best course would be to choose a nurse tree, that, in the particular situation, will not outpace the Blackbutt but will for the time being give the shelter, required density, and cover to the forest floor. However, a spacing that would equal certainly not less than 1,200 to the acre—say 8 x 4 triangularly—but it might be that denser than that would be advisable, any tendency towards overcrowding being rectified by early thinning.

Its need of good soil and not severe climatic conditions limit the situations in which Blackbutt can be successfully grown, but it is far too valuable a tree not to be planted to a considerable extent wherever the conditions favour it and land can be made available for the purpose.

Chapter LXIV.

CLASS 3—SLIGHTLY FROST HARDY EUCALYPTS (Continued).

Eucalyptus resinfera (Red Mahogany).

Red Mahogany is a medium sized tree—about 100 feet in height and up to 6 feet in diameter—of great value on account of the great strength, beauty and great durability of its timber.

It is confined to New South Wales and Queensland. Its range is along a fairly wide coastal belt from Northern Queensland, well down but not to the south of New South Wales.

Red Mahogany is one of the group associated with *E. robusta*, and there are several varieties, and seemingly some intermediate forms between it and others of the group. As a consequence there has been much confusion and some accounts are very contradictory both as to the size and peculiarities of the tree, and as to the timber. One authority refers to it as "one of the largest forest trees of the State," meaning New South Wales; another as being a tree of 100 feet height and 2 to 4 feet diameter.

Timber.—Mr. Maiden recorded it as "one of the most valuable hardwoods of the State," "a grand furniture wood," "one of the most durable timbers we have, being resistant to damp and attacks of the white ants." Whilst Richard T. Baker

gives the following:—"It will not last in damp, unventilated situations, and so is condemned for flooring joists, otherwise it is a good average house timber."

The following appears in J. H. Maiden's *New South Wales Forest Flora*:—"In the early days of settlement—that is to say, during the first decade of the nineteenth century—some red mahogany was cut from the bush, perhaps in the neighbourhood of Sydney itself, and along with three other logs, each some 15 feet or 18 feet in length, was shipped as a sample of New South Wales hardwood to England. The wood was put aboard a vessel known as the *Boyd*, which is believed to have been a brig of some 500 tons register. The *Boyd* sailed for New Zealand, where she proposed to load kauri gum for the Cape, in the year 1809, having on board seventy white people and a number of Maoris, also a valuable cargo. In Whangaroa harbour, however, a terrible fate awaited the ship and her crew. The *Boyd* fell into the hands of the Maoris, and the unfortunate white people on board, with the exception of four—two women and two children—were killed, cooked, and eaten. The vessel herself seems to have been run aground and burnt to the water's edge. The history of the unhappy voyage has since been embalmed amongst the most stirring events of seafaring life in Australian waters, and the charred remains of the ship have been traced with recurring interest as they have drifted from time to time about the harbour of Whangaroa, sometimes projecting above the surface, sometimes seen a few feet below, and occasionally completely lost for months together in the mud. A log of this timber was presented by Mr. A. W. Farquhar to me in 1895, when Curator of the Technological Museum, and it seemed none the worse for its immersion of eighty-six years."

That the timber is very durable there can be no doubt, it is very hard when thoroughly seasoned, very strong, approaching in strength that of the strongest Ironbarks, for it almost ties with "Broad-leaved Ironbark" (*E. siderophloia*) for the place of fifth strongest of all the Eucalypts, and is so not far short of twice as strong as Jarrah. It dresses well, and is an exceedingly handsome timber.

Rate of Growth.—The same confusing accounts occur in connection with its rate of growth as do in the cases of the size of the tree and the quality of the timber, undoubtedly arising from the same cause, namely confusion between the different varieties, and possibly between different species.

Whilst the source and trueness of seed is always of importance, it is especially so in connection with many Eucalypts, notably in the case of all in the group to which Red Mahogany belongs.

Red Mahogany's rate of growth falls into the category of "medium." In some places it shows, at least for a time, fairly rapid growth—and that good early growth is very important—but on the average it is not a fast grower, but its rate is far beyond that of the slow growers. At the Taranaki Forests it has grown 11 feet in three years, and rather better growth in the plantation of the writer, but it is doubtful whether generally that rate would apply.

Climate and Soil.—Red Mahogany will do no good in a severe climate and where the soil conditions are poor, but it will stand slight frosts, but the actual degree depends upon where the seed has been gathered and to what variation it belongs. It is suitable for semi-coastal areas in New Zealand from Taranaki and Hawke's Bay northwards, but the situation must be favourable. It is promising well in special locations in parts of South Africa.

Like many of the Eucalypts, it requires, for the best results, a fairly good to good deep porous moist soil, and generous rainfall.

Sylvicultural, etc.—Much the same treatment as many others. Red Mahogany is about an equal shade bearer to Saligna.

Eucalyptus eugenioides (White Stringybark).

Eugenioides is one of the most valuable and probably the most durable of the Stringybarks, and a very desirable tree for afforestation purposes.

It extends, mostly in the coastal ranges, from South and Eastern Victoria through New South Wales to Southern Queensland.

Size and Form.—Eugenioides is a graceful, very straight, slender, central-stemmed and slender-branched tree, attaining a height up to 200 feet and a diameter of 3 feet. Usually its size is considerably less, and most descriptions give its height as about 100 feet. However, the height of 200 feet is given under authority of the Victorian Forests Commission.

The tree is a remarkably straight grower, even when growing separately. In the latter case the branches are naturally heavier, but when grown under forest conditions the stem

is quite clear for a great distance. The bark is very thick, stringy, and loosely matted, of a brown-red or reddish colour; it is very distinct from the barks of the other Stringybarks.

Rate of Growth.—Though somewhat slow at first Eugenioides is a rapid grower, not one of the most rapid but well up in rate among the quick growers, and probably the most rapid of Eucalypts that are very durable in contact with the ground.

It reaches light-weight pole size in 10 to 12 years, but of course at that age would carry a large proportion of sap. Telephone poles of such sappy timber have been imported into New Zealand, and have rotted to a heart of less than half the original diameter in seven or eight years. The use of such timber, especially without any preservative treatment, brings undeserved discredit on the timber.

In eight years from seed a Eugenioides has reached 50 ft. in height and a diameter of 11 inches over bark at 4 feet from the ground, and transplants in the plantation 7 years old 30 ft. by 5 in., in the plantation of the writer.

Timber.—The timber of Eugenioides is the strongest and probably the most durable of the Stringybarks, and in these qualities approaching those of the better Ironbarks. It is hard, easily worked, and dresses well, and is fissile. It is a timber of high quality for many purposes—structural, house building, railway waggon building, sleepers, poles, fencing, etc. It shows great durability in contact with the ground, and with its long very straight clean growth is especially suitable for electric power, telegraph, and other poles. A tall pole from a fifteen year old tree was sound as a flagstaff after being in the ground fifteen years.

As it reaches pole size in some situations in early life, poles from such should be treated with preservative, for the sapwood readily takes in the preservative, and so the early decay of the sapwood would be prevented, and it would act as a protection to the heartwood.

Climate and Soil.—Eugenioides will grow in comparatively poor soil—not very poor—if the soil is not too hard, but to obtain really good growth the soil should be of good quality, free, and deep. It is fairly hardy, standing light to even fairly heavy frosts quite well, if grown from seed obtained from trees growing in the colder higher parts within, say, the southern part of its natural range. It grows at elevations up to 3,000 feet. If on the other hand the seed has been collected in low-

land localities in Northern New South Wales or Queensland the plants are not likely to stand any but light frosts.

Eugenioides has been grown successfully in many parts of New Zealand, even as far south as Banks Peninsula in the South Island, and throughout most of the North Island, both semi-coastal and inland. In the Waikato it has done excellently, and also even at Rotorua. Eugenioides, like most of the Eucalypts, thrives best with a generous rainfall.

Sylvicultural, etc.—As already inferred seed should be obtained from situations as nearly as possible similar to where it is to be grown. In fact it would be better to err on the side of getting it from situations slightly severer than where it is to be grown.

Eugenioides is not a very good transplanter. With good, properly wrenched plants, handled and planted with care in suitable weather, quite satisfactory results can be obtained, but with poor plants, or careless handling or planting, a high percentage of failures will probably result.

The transplants are rather slow to get away, and show slow growth during the first or even the second and third years, but later make good growth. To have good success with Eugenioides the soil should be well prepared, unless it is of such a nature that it is in a fresh free condition and without heavy weed growth. Eugenioides is such a valuable tree that it is well worth good soil, thorough preparation, careful planting and attention for the first year so that a full stand of even growth may be assured. It grows well in pure plantation, fairly closely spaced, in mixture with other species of Eucalypts of equal rate of growth, and in mixture with conifers, even with Insignis, if soil conditions are specially favourable to the Eugenioides, or, say, in alternate rows with Macrocarpas, the latter being planted first if the position is somewhat exposed, and in two or three years the rows between the Macrocarpas ploughed, etc., before planting the Eugenioides.

Eucalyptus Muelleriana ("Yellow Stringybark").

Muelleriana is another of the Stringybarks, and has a more extended natural range than some of the other Stringybarks, Eugenioides for example. It occurs in South Australia, Victoria, and New South Wales, and possibly in Queensland.

It produces a valuable timber, and is certainly one of the trees that should have an important place in afforestation in situations suitable to it.

Size and Form.—Muelleriana has been recorded as up to 200 feet in height, but that height is certainly extreme. 100 to 150 feet are more usual heights, and frequently less, with a diameter of 3 feet, but diameter growths up to 8 feet are recorded. It forms a stately tree with a very straight fine bole and somewhat heavy head, and where not confined somewhat heavy limbs.

Rate of Growth.—As a young plant Muelleriana often shows promise of distinctly rapid growth, but taking later growth into consideration the general rate should be classed as medium or moderately quick to medium, that is comparing it with the rapid growing Eucalypts such as Fastigata, but as a tree that produces high quality and very durable timber, and comparing its growth with the high class slow growers it is quick.

Timber.—The timber is heavier than that of Eugenioides and slightly heavier than that of Blackbutt. It is very similar in quality to that of Blackbutt, and also to that of Eugenioides, and suitable for the same purposes, showing great durability in contact with the ground, some consider more so than that of Eugenioides.

Climate and Soil.—Reports as to degree to which it can withstand frost are somewhat conflicting, doubtless due again to the source of the seed. In its natural habitats it does not ascend to nearly the same altitudes as does Eugenioides, but it will stand fair frosts. It is more of a low country tree than Eugenioides, and will thrive in sand and sandy clays, and in fairly good deep, and not too stiff or heavy, soils.

Sylvicultural, etc.—Muelleriana has not so far been planted to any great extent anywhere, and consequently there is little information as to its best treatment.

The seed germinates freely, and the seedlings thrive well and make quite fair growth. They are not difficult to transplant or establish, and stand, for a Eucalypt, fair shade. Much the same treatment as to spacing, etc., as in the case of Eugenioides would probably answer, the forester relying on thinning to rectify possible over density and underplanting later in life.

E. capitellata (Brown Stringybark).

Another Stringybark, and though a fairly valuable tree, both Eugenioides and Muelleriana will produce somewhat better timbers, and Eugenioides will certainly grow quicker. Blaxlandi is a near ally, and better.

Eucalyptus rostrata (Murray River Red Gum).

The tree is very commonly known as Red Gum, but to distinguish it from other Red Gums, such as tereticornis, the Forest Red Gum, the name Murray River Red Gum best suits it, seeing that though widely scattered it grows in great quanties along the Murray River.

The Red Gum is one of the most valuable and most widely known and planted of all the Eucalypts. It has been planted in practically all countries having warm to moderate climates, and has shown a wonderful capacity to adapt itself to the many varied conditions, and to thrive surprisingly.

Its natural range extends through every state in Australia, a wider range than, perhaps, any other Eucalypt, but the Murray River in Victoria and into New South Wales may be considered its chief habitat. Though a great moisture lover, provided the moisture is not stagnant, it will thrive under a wide range of conditions, and therefore, considering the value of its timber and that it is a fairly fast to a fast grower, it should hold a very important place among trees for re-afforestation in Australia and for afforestation in parts of South Africa and throughout the North Island of New Zealand, and to a limited extent in the most favoured parts of the South.

Size and Form.—The Red Gum does not rank among the great trees, for under no circumstances is it a tall growing tree. Under forest conditions that are favourable to it, it reaches a height of 100 feet or possibly a little over, with a diameter of 3 feet or more, but where it is growing independently the height does not usually exceed 60 ft., but the diameter is much greater, sometimes as much as 10 feet. Under such conditions it is usually of very irregular form, with wide spreading heavy limbs.

Grown under forest conditions it is a fairly straight, but by no means a quite straight, tree.

Rate of Growth.—The rate of growth of the Red Gum is irregular and unsatisfactory in situations that do not suit it. Very great differences are observable in the rate of growth in situations separated by only a short distance, and consequently the Red Gum has come to be looked upon by most as a slow grower. This is by no means fully warranted, for it has proved to be a rapid grower in many places, and even a very rapid grower in some.

The truth is that the Red Gum cannot be classed as Fastigata, Obliqua, and others as reliable growers throughout their wide range, but as a tree that will fail to give satisfaction in the greater number of situations, and thrive excellently in the few. Careful seed selection and testing each situation by experimental planting are imperative safeguards before extensive planting of it is undertaken.

Baron von Mueller recorded as follows:—"In Mauritius and Reunion it resisted the hurricanes better than any other Eucalypt; in the latter island the Marquis de Chateauvieux observed it to grow 65 feet in six years."

It has grown as much as 17 feet in 3 years in the plantations of the Taranaki Forests, where it was, for the reason above given, only planted experimentally.

There are many records of rapid growth, but the writer prefers to class it as a medium grower.

Timber.—The timber of the Red Gum is very valuable, and is deservedly held generally in very high repute, specially so for certain purposes. It is very hard, tough, interlocked, strong, and very durable. In some cases it is easy to work, in others hard. It is red in colour and very handsome. The timber is used for many purposes, such as bridge work, wheelwright's and carriagebuilder's work, wood blocks, railway sleepers, heavy furniture, for which it is a very handsome timber.

The timber from trees grown where there is ample moisture is in the highest repute, whilst that from districts where there is a low rainfall and lack of moisture seems to be of poorer quality.

Climate and Soil.—The Red Gum is fairly hardy and will stand slight frosts. It will grow in comparatively poor soils, but to thrive well and be profitable it should have a deep free fertile soil with plenty of moisture, the more free moisture, not stagnant, the better the Red Gum will thrive. In addition to soil moisture a generous rainfall is an advantage.

It has been grown, and has mostly thriven, almost throughout the North Island and parts of the South Island of New Zealand, and is showing promise in parts of South Africa. As already mentioned, it has thriven well in many parts of the world, including France and Italy.

Sylvicultural, etc.—The seed has a high percentage of germination, and should be sown very sparsely in narrow rows, otherwise the seedlings will be over spindly. The seedlings

are not among the best transplanters, but with care and judgment quite good "takes" can be secured. The transplants are rather slow to come away, and consequently will suffer where weed growth is bad, and should have careful attention.

River banks, alluvial flats with plenty of moisture, the bases of terraces, or of cliffs or hills where there are considerable springs or much moisture are suitable situations, or any place where the soil is good, free and moist, are positions where the most satisfactory results may be looked for.

Dense planting, thinning, and underplanting are advisable where the planting is "pure." The Red Gum is a light demander, and therefore special care and knowledge is required when mixing with either heavy foliaged other species of Eucalypts or with conifers. The conditions that would favour the Red Gum most would be too moist for most conifers, but such as Bald Cypress, Western Red Cedar, or even Redwood, might not find it so, but it is very doubtful whether any satisfactory mixing of Red Gum with conifers could be accomplished.

Eucalyptus tereticornis (Forest Red Gum).

This other Red Gum, the Forest Red Gum, will grow under conditions that the River Red Gum will not, but it is an ill growing tree, not a rapid grower, and with these faults has nothing to recommend it as against many other species for afforestation purposes.

Eucalyptus goniocalyx (The Mountain Gum).

The Mountain Gum belongs to Victoria, New South Wales, and part of South Australia. As its name indicates, its natural home is in the mountains, and there is found at elevations up to 4,000 ft. It thrives best in damp situations, in deep valleys and mountain slopes.

Size and Form.—The Mountain Gum is credited by Victorian authority as reaching a height of 200 feet, and a diameter of 6 feet, but its usual size is considerably less. However, it is a very fine tree.

Rate of Growth.—The Mountain Gum's rate of growth is somewhat uncertain. In some places it is rapid, in others only medium. Whether this variation is due to lack of selection of seed or perhaps to a confusion of varieties, if not of species, it is at present hard to say. But as the rate of growth is rapid

in some places, selection of seed from trees in such places and the raising and establishment from that seed in similar situations ought to ensure rapid, or fairly rapid, growth.

Timber.—The timber is hard, tough, hard to split, strong, and exceedingly durable. It is serviceable for all the purposes to which similar timbers are put, its extreme durability being its chief quality.

Climate and Soil.—The Mountain Gum is fairly hardy, standing slight frosts. No doubt plants raised from seed collected from the higher elevations—up to 4,000 feet—at which the Mountain Gum grows would stand quite considerable frost. As its natural habitat is in the valleys and southern slopes where the mountains are heavily wooded, the indications are that it thrives best when sheltered and where there is plenty of moisture, and it requires fair to good quality of soil.

Sylvicultural, etc.—There is no information available as a guide to the most suitable treatment, and pending further knowledge ordinary methods, etc., applied to many Eucalypts should be followed.

It does not seem advisable to attempt any extensive planting of the Mountain Gum without being absolutely assured that the seed used is true to species, and not from trees belonging to one of the many varieties that are not true to type, and that the seed has been collected where the situation is similar to that in which it is to be grown. And further, until its suitability to the situation is proved plantings should be kept within the limits of reasonable experiment, for the Mountain Gum cannot be considered a reliable grower.

Eucalyptus sideroxylon (Red Ironbark).

As has been stated, it is not intended to deal with more than a few Eucalypts in this work. The selection is based chiefly on three qualities, viz., (1) high quality and wide utility of timber, (2) adaptability for afforestation purposes in various parts, and (3) rapidity of growth. Some few that fall behind in one quality or another are shortly referred to because they will thrive under climatic or soil conditions unsuitable to most of the others. The Red Ironbark is one such.

The Red Ironbark is not a fast grower, in fact it is generally quite a slow grower; nor is it a large growing or a very symmetrical tree, but it produces a valuable hard strong and very durable timber, though not equal to that of the best Iron-

bark, the Grey Ironbark (*E. paniculata*). The reason for its mention is that it grows on poorer soil, much poorer, than most of the others, and is hardier than the other Ironbarks.

The Red Ironbark has been grown successfully and to useful size in the northern half of the North Island of New Zealand, and gives promise of success in parts of South Africa.

Chapter LXV.

CLASS 4—VERY SLIGHTLY FROST HARDY EUCALYPTS.

Eucalyptus microcorys ("Tallow-wood").

Tallow-wood is one of the most valuable of the Eucalypts for afforestation purposes. The late Mr. J. H. Maiden, in referring to this tree, expressed the following opinion:—"I would express the opinion that, after Ironbark, Tallow-wood is the most valuable of our hardwoods." The name Tallow-wood is applied to this tree because of the peculiar greasy nature of the wood.

The natural habitat of the Tallow-wood is along the coastal area of New South Wales and Queensland. The width of the belt is quite narrow, not going inland more than about 30 miles. It ascends the coastal ranges to elevations not exceeding about 2,000 feet, growing on the mountain slopes and on the tableland.

Size and Form.—The Tallow-wood reaches the dimensions of a very large tree. Its height is from 100 to 150 feet, but on occasions considerably greater. From 80 or 90 up to 120 feet length of saw logs can be cut from a tree. It is a handsome tree with a straight clean bole. The base is usually wide spread and somewhat buttressed, and from that for some little distance up the bole has a considerable taper. Clear of the widened lower part the diameter runs from 4 to 7 or 8 feet. The following description given in J. H. Maiden's *Forest Flora of New South Wales* will indicate to what very fine dimensions this tree reaches:—"The Tallow-wood is the chief glory of this magnificent forest. A monster fell a few hundred yards from our party, and the noise of falling was like the noise of a park of artillery. We took the following dimensions of this prostrate

giant—15 feet of stump had been left. It was 62 feet more to the first fork, and its girth was 27 feet 4 inches at 3 feet from the ground. A log of 14 feet 2 inches in girth in the centre, 8,820 feet was calculated in this log. Many trees will give 12,000 to 14,000 feet of timber each. We came across a fine tree 65 feet to the first branch."

Rate of Growth.—The Tallow-wood is distinctly a fast grower where conditions suit it. It is not one of the most rapid but should rank among the fast growers. Its place in comparative rates comes after E. eugenioides. It has made excellent growth in parts of New Zealand. An independent tree grown direct from seed at the plantation of the writer in Taranaki has in 8 years reached a height of 40 feet with a diameter 4 feet from the ground of 8 inches. In the plantation under forest conditions 7 year old trees are 20 to 25 feet high, which would give an annual height growth of approximately 3 feet.

Timber.—The timber is exceedingly valuable. It is hard, heavy, 59 lbs. to the cubic foot, strong and durable, close grained, hard to split, and hard to burn, and shrinks less than most. It is of special value for floors, decking, bridge building, sleepers, fencing, general building, etc.

Climate and Soil.—Again in this instance as in many others the source of the seed is important. In some cases Tallow-wood withstands a fair frost, in other cases individual plants here and there, sometimes a considerable proportion of the whole and sometimes a small, will be caught by a comparatively light frost, indicating a mixture of seed collected from different situations. However, the Tallow-wood must be ranked with those species that are not fitted for severe climatic or hard or poor soil conditions. To thrive well it requires fair warmth and shelter, and well drained fairly good quality of soil. A fairly stiff soil, so long as it is deep and well drained and has a liberal supply of humus will do, but a deep, porous loamy soil with plenty of moisture is best.

Sylvicultural, etc.—The Tallow-wood is not an especially easy plant to raise and deal with. It requires distinct care throughout if a reasonably high percentage of success is looked for. Besides the situation being favourable, the soil requires to be cultivated before planting is done, and the plants either actual cultivation or thorough weeding. The tree is such a valuable one for afforestation purposes that success with it will fully compensate for the extra care necessary.

Tallow-wood will thrive in good situations in the warmer parts of New Zealand and in parts of South Africa. And where it thrives a reasonable number of it should be planted.

Eucalyptus paniculata (White, Black, or Grey Ironbark).

The Grey Ironbark is, from a timber quality point of view, the king of the Ironbarks, and therefore of all the Eucalypts. For many purposes it ranks as one of the most valuable trees in the world, as its timber combines hardness, very great strength, and very great durability. It is confined to the coastal belt of New South Wales and Queensland.

Although there is nothing that warrants separation botanically, there are three marked variations in the trees and their timbers. These three varieties are distinguished under the names "White," "Black," and "Grey" Ironbark. They all produce timber of very high qualities, and in the timber trade are treated as one, but the "White" is the stronger timber, and for afforestation purposes it will be important to ascertain which variety may be generally the best, or which variety will best suit certain situations.

Size and Form.—Compared with the giant Eucalypts the Grey Ironbark is a small tree, but generally it would be classed as of medium dimensions. Its height is usually from 60 to 80 feet, possibly somewhat higher in some localities, with a diameter of from 2 to 4 or even 5 feet, but a height of 152 feet and girth of 7 feet 10 inches has been recorded.

The tree is usually straight, or fairly straight, clean stemmed with little taper, and free from limbs for the greater portion of its height.

Rate of Growth.—Except for a tree having very high qualities, the ordinary rate of growth of the Grey Ironbark would not recommend it for afforestation purposes, but its timber is of such outstanding quality and value that the comparatively rather slow growth of the tree does not warrant its exclusion from plantations where the climate and situation suit it.

There is reason to believe that its sensitiveness to climatic conditions and slowness of growth have been unduly overstated. There are indications that it, or at least, one of its varieties, is hardier and will thrive in situations considerably extended beyond its supposed limits, and that its rate of growth is considerably beyond that generally credited to it. It should, it seems, be classed among the "medium" and not the "slow" growers.

It is reported that in the Auckland Province Grey Ironbark shows promise.

At the plantations near New Plymouth of the Taranaki Forests Grey Ironbark (planted under name as "Red" and "White" varieties) is giving great promise, having grown, in extreme, as much as 15 feet in three years, but the average growth would be from 6 to 9 feet, equalling 2 to 3 feet per year.

Sixty to seventy foot wharf piles with a diameter from 16 to 18 inches at the thick end, show approximately 60 annual rings, but doubtless these dimensions might be attained, in suitable situations, in considerably less time—say 45 to 50 years—and these are very heavy piles.

The late Sir David Hutchens records in his *Discussions on Australian Forestry* that Grey Ironbark has been found to grow fast enough for planting purposes, and is being largely planted there mainly for sleepers. He also makes the following statement:—"A tree that is at the same time durable, quick growing, and strong is difficult to find in all Australia, those perhaps coming nearest to it are Grey Ironbark (*E. paniculata*) of New South Wales, and the Yellow Stringybark (*E. Muelleriana*) of Victoria. These are both medium fast growers."

Timber.—The timber is of great strength and durability, it is hard, fairly straight in the grain, and, for an Ironbark, splits easily. The weight of the timber is different in each variety, 64 lbs., 69½ lbs., and 63½ lbs. per cubic foot, according to Richard T. Baker. It is a timber of very great value for many purposes. Marine works (piles, stringers, beams, braces, etc.), bridge work, poles, posts, blocks, any strong heavy constructional work.

Taking Richard T. Baker's Transverse Tests of Timbers, the "White" variety is highest in breaking load in lb. and in modulus of rupture in lbs. per square inch. The "Black" is next in order, but all are very strong timbers, and rank fourth in strength of all the Eucalypts. The "White Ironbark" is excessively hard. Very many timbers are sold as Ironbark, and it is impossible now to get a shipment of any one species, and practically impossible to get a shipment that is confined to a mixture of true Ironbarks. Usually several other species, that are not Ironbarks at all, are included, and frequently very few if any of the true Ironbarks are included. Though Richard T. Baker, in his work *Hardwoods of Australia and their Economics*, in his grouping of the Eucalypts according

to their bark characteristics, shows eleven Ironbarks, there are only four species that are recognised as true Ironbarks, viz., paniculata, siderophloia, creba, and sideroxylon.

J. H. Maiden, in his *Forest Flora of New South Wales*, gave a very informative description of "How to tell Ironbark." It is as follows:—"It is easy, in a few words, to give a definition of Ironbark. Of course, if the bark is available the thing is simple enough, for most of the barks are characteristically furrowed and rugged. To describe it we must take note of a variety of circumstances. It is heavy (almost the heaviest of our hardwoods). It is hard, as may readily be seen if touched with a plane or a nail be driven (or attempted to be driven) into it. Its most characteristic property, however, is a certain 'gumminess' in working, which will be brought out under the plane, and its horny texture. The result is that when planed the Ironbark shows the appearance of more or less parallel striae, or lines of close textured wood, strongly resembling horn, while between these the wood has a more open grain, showing narrow pits which may be seen, even by the naked eye, to be filled by a substance of a resinous texture. In some specimens it is not easy, however, to make out these lines of horny-textured wood, but the resin pits appear to be always present. Ironbark is more or less curly in the grain, consequently it often gives trouble to plane to a perfectly smooth surface. If a blunt tool is used the Ironbark tears in fairly regular blocks, while to get a perfectly smooth surface the wood often requires to be traversed with the plane, or even to be gone over with a steel scraper."

Climate and Soil.—The Grey Ironbark requires a warm climate with no, or only slight, frosts. That it will thrive so well, making good growth, as far south as New Plymouth, where it has withstood many slight or moderate frosts without injury, when Tallow-wood (*E. Microcorys*) right alongside has been touched, shows it is not extremely frost tender. The aspect, configuration, and soil conditions are more important than the general climatic conditions, and these being absolutely ideal at the Taranaki Forests plantations, accounts for the success with Grey Ironbark there, and the success and extraordinarily rapid growth of so many species.

In its natural habitat the Grey Ironbark grows extensively on ironstone ridges and poor dry land of practically no value for any other purpose than growing such trees as will grow on it. Why it should naturally confine itself to such poor soil

conditions is impossible to understand, for under cultivation it does not thrive in poor soil conditions, and responds wonderfully to better soil and ample moisture.

A deep porous loamy soil with plenty of moisture and moist atmospheric conditions, sheltered, not exposed conditions suit it best.

Sylvicultural, etc.—There is practically no information available as to best methods, and until there is, foresters must just depend on their own judgment in each situation.

Though not one of the best to handle and transplant, very good results can be obtained with care. The soil should be good and well cultivated, and the young transplants should be properly attended to in the matter of cleaning for the first year or 18 months.

Eucalyptus siderophloia (Broad-leaved Ironbark).

Full details of this Ironbark are not necessary; practically all that applies to the Grey Ironbark applies to this. Its range is more extended, that is, it is found further inland. It is a larger tree, reaching 100 feet and over in height. The timber is very strong, and generally of high quality, but its reputation for extreme durability is not so well established, and the trees have the fault—that is the mature trees—of frequently being pipy. However, its timber is of great strength and high quality.

The rate of growth is recorded as "medium," and it is showing some success in the northern half of the North Island, New Zealand.

At the plantations of the Taranaki Forest, near New Plymouth, it does not give nearly the same promise as the Grey Ironbark, in fact little promise at all.

Eucalyptus diversicolor (Karri).

Karri is undoubtedly of great value for afforestation purposes, for which it possesses several qualities. It grows to a great size, produces a very valuable timber, is a rapid grower, easy to establish, and one of the densest growing and best natural reproducers amongst the Eucalypts.

Its range is over a comparatively limited fertile area in South-western Australia.

Size and Form.—Karri is the largest tree in Western Australia, and it is thought probable by some that it may have

been the largest in all Australia. However that may be, it reaches 300 feet or more in height. The late Sir David Hutchen measured a Karri 270 ft. high and 11 foot diameter. It is a very dense growing tree, with long clean, very straight boles, with hardly any taper.

Rate of Growth.—A distinctly rapid growing tree, in some situations outstripping the Insignis pine, averaging 4½ feet over a period of 18 years in height growth and ½ an inch diameter in one part of South Africa, and very nearly that rate in other parts. The Karri has been planted there to some extent.

A re-growth at Karridale in 30 years made average diameter of from 18 to 24 inches.

Timber.—It is hard, heavy (58 lbs. per cubic foot), elastic, and tough, having an exceedingly interlocked grain. It has special value for bridges, beams, rafters, etc., having great lateral strength, and for such purposes is superior to Jarrah. It has a wide range of utility, which is extended on account of the great lengths and large dimensions that are procurable.

Climate and Soil.—Karri will not stand severe conditions. It requires fair shelter, warm and somewhat moist conditions, and a good soil, the deeper the better, and porous, but with liberal moisture, although it gets on with less soil moisture provided the atmospheric moisture or the rainfall is good. Under such conditions, which can be obtained and can be afforded for such a fast growing valuable tree, it is an exceedingly satisfactory species to deal with.

Sylvicultural, etc.—Karri is easily raised, easy to transplant, makes good early growth, and so soon gets away from the weeds and any ill effects from slight frosts.

It should be planted densely. The Karri and Gigantea are the densest growing Eucalypts. Dense planting will give long thin poles, and thinnings that must necessarily follow will produce valuable material, later when the forest floor begins to be rather open underplanting with pines is advisable. The conditions which suit Karri best will suit Redwood and such like. Even Western Red Cedar might be tried.

Eucalyptus acmenioides ("White Mahogany").

White Mahogany is confined to New South Wales and Queensland, occurring in coastal districts and table-lands, extending 100 miles or more inland, where it withstands consider-

able frosts. The position of White Mahogany for afforestation purposes is yet in doubt, but its timber is very valuable, chiefly on account of its great durability, and therefore this species should be given a good trial in New Zealand and South Africa, as well as in its homeland.

Size and Form.—The White Mahogany is a tall straight stemmed tree, reaching 100 feet, clear of limbs for far the greater portion of its height, slightly swelled at the base above which there is remarkably little taper. It reaches a diameter of 5 feet and over. The bark is stringy, and it is sometimes classed as a Stringybark and sometimes as a Mahogany.

Rate of Growth.—Its rate of growth has been classed as "medium," but there does not seem to be any precise information available as to its rate of growth under forest conditions beyond its natural habitat. Young plants are making satisfactory and fairly quick growth in Taranaki.

Timber.—The timber is hard, close grained, heavy, weighing 64 lbs. per cubic foot, and extremely durable. It is one of the finest and most durable of New South Wales timbers, and is a first-class timber for all the purposes that the highest quality Eucalypt timbers serve. It is also high up in the list of quite the strongest of these timbers. Posts of this timber have been found to be quite sound after 50 years.

Climate and Soil.—White Mahogany in the main requires a warm climate, but if seed is collected from the higher inland positions the plants will withstand a fair frost, but not by any means a severe one. Young plants at the Taranaki Forest plantations have shown no ill effects there during two winters, and are making good progress.

It should do well in many situations in the North Island, New Zealand, and in South Africa. It seems to thrive best under the same conditions that most of the Eucalypts do, that is in deep, porous, moist, good quality soils, where there is shelter and warmth, and requires similar treatment to most others.

Eucalyptus corynocalyx (Sugar Gum).

The Sugar Gum is a South Australian tree, and in that State the Forest authorities have planted it to some considerable extent with success, and it has been planted with success in parts of South Africa, and in one or two instances in New Zealand.

It is a medium sized tree of rather irregular growth, the stems all being more or less crooked, but the timber is of high quality, hard, and very durable.

Its rate of growth is very irregular, doing well in some places and not so in others, but where conditions are suitable it grows fairly rapidly.

The Sugar Gum is referred to here because it, unlike many other species, will thrive well in stiff clay or otherwise hard ground, and with a comparatively low rainfall.

It is not recommended for afforestation purposes, except where the conditions suit it better than other species, for the following reasons:—It is a crooked grower, it is uncertain as to rate of growth, and it is a decidedly bad transplanter. If for some special reasons it is desired to grow it, it is best to drill in or spot sow the seed.

Chapter LXVI.

CLASS 5—FROST SENSITIVE EUCALYPTS.

In this group there are few Western Australian trees of outstanding quality, but only one of them has an assured place in connection with afforestation.

The five are Eucalyptus marginata (Jarrah), E. cornuta (Yate), E. salmonophloia (Salmon Gum), E. loxophleba, and E. Jacksoni (Red Tingle Tingle).

Eucalyptus marginata (Jarrah).

Jarrah is one of the most widely known timber trees of Australia, and one of the most important.

Though occupying first place among the important timbers of Western Australia, the Jarrah is confined to a comparatively limited range along the coastal belt of the south of that State, and the Jarrah forests, unlike those of Karri, are very poorly stocked. Apparently the Jarrah forest suffers much more severely from the effects of fire, and it is naturally much less freely reproduced than that of Karri.

Size and Form.—Jarrah is a much smaller tree than Karri, its usual height being barely 100 feet, with a diameter of

5 or 6 feet. One tree was measured and found to be 145 feet high, having a 95 feet bole with a diameter of 8 feet at the butt. These measurements are given as extreme. Whilst a proportion of the trees are fine straight-boled trees very many are unshapely. This is doubtless due to the exceeding openness of the natural forests, and would be rectified by closer planting when used for afforestation purposes, if its slow growth does not exclude it entirely from such.

Timber.—The timber of the Jarrah is deservedly held in very high repute, and is ranked as one of the finest of the Australian timbers. Its outstanding qualities are great durability, beauty of texture and colour, and easy working. It has a very wide range of utility. Its uses are set out by Richard T. Baker in his *Hardwoods of Australia and their Economics*, thus:—"It is red-coloured, of medium hardness, straight in grain, fissile, and, owing to its durable nature for outdoor work, is used for bridge decking, wood blocking, piles (being reputed to stand well in the ground and water), carriage and waggon work, house construction, decorative fences, rustic boards, railway sleepers, telegraph poles; said to be immune from white ants; and to be distinguished from Karri by its straight grain and burning."

But notwithstanding its many good qualities, it has to be remembered that it is deficient in strength. It ranks, in strength, quite low down among the better class Eucalypts—about thirtieth in order.

Rate of Growth.—Its rate of growth cannot be described as other than slow, too slow compared with many valuable Eucalypts to warrant its selection for afforestation purposes in any of our southern lands. From amongst the same class of trees as Jarrah, Karri offers infinitely better prospects.

The only reason that Jarrah has been referred to is that being so well and widely known its absence would have seemed strange.

Eucalyptus cornuta (Yate).

The Yate is a tree of very great value for afforestation purposes in the warmer frost-free, or practically frost-free, situations. Its home is in the south of Western Australia.

Size.—Yate is a medium sized tree, reaching 100 feet in height, with a diameter of about 3 feet.

Rate of Growth.—Yate is a distinctly rapid growing tree in situations that suit it. It does not come into the first rank of

rapid growing Eucalypts, but certainly into the second rank. Among those which produce timber of great strength and generally of very high quality Yate takes first place in rate of growth.

It is very surprising that its pre-eminent suitability for afforestation, when the production of high class timber is aimed at, has been so little recognised.

Timber.—The timber of the Yate is of the highest quality where great strength and durability is required. It is one of the finest hardwoods, and exceeds all in strength. It is probably the strongest timber in the world. It is a hard, close grained, interlocked, heavy (63 lbs. to the cubic foot), durable timber, suitable for all purposes for which the best hardwoods are used.

Climate and Soil.—The Yate is probably the hardiest of the group, and would seem to adapt itself to a wider range of conditions than any of the others, with possibly the exception of Karri. It requires a warm climate, but will stand very slight frosts. It thrives best, as do most of the Eucalypts, in a deep free loamy soil, with plenty of moisture, but though thriving well where the rainfall is generous (50 to 70 inches), will also grow where it is under 20 inches, and the soil conditions are not nearly so good.

In New Zealand it has been very little planted, and there is only suitable for the more favoured parts. Young transplants are doing remarkably well at the plantations of the Taranaki Forests.

Yate has been planted in South Africa, and in parts is growing well, and there promises to be, in suitable situations, a species of much value.

Sylvicultural, etc.—Practically no information is available, so far, as to the best treatment. The seed shows a very high percentage of germination, and comes away freely. The seedlings are inclined to be tap-rooted, and therefore care should be taken to wrench at the proper time, and in a manner to promote better root formation. Notwithstanding the unpromising appearance of seedlings when lifted they, with care, show a high percentage of success, and where soil is of suitable quality and well prepared, make very good early growth.

Eucalyptus loxophleba (York Gum).

York Gum is another of the Western Australian species. It is not nearly so well known as some of the others, but its

timber is of high quality, hard, heavy (63 lbs. per cubic foot), of great strength, and exceedingly tough.

The York Gum is a comparatively small or medium sized tree, reaching a height of 100 feet.

Of its fitness for afforestation purposes there is no information in the possession of the writer, but it is referred to here because it is reputed to be a fast grower, and because its timber is of high quality and is very handsome.

E. salmonophloia (Salmon Gum) and E. Jacksoni. (Red Tingle Tingle).

Both these produce timber of high quality. That of the first is tough with interlocked grain, and is one of the hardest and heaviest of Eucalypt timbers; it is handsome and of a deep red colour; that of the second is tough, fissile, and bright red.

Both are Southern Westralian trees, and thrive where the rainfall is low, for which reason they are mentioned here. The first reaches a height of 100 feet, and the second 200 feet.

As to their rate of growth or suitability for afforestation purposes, there is practically no information.

Syncarpia laurifolia (Turpentine).

Outside the Eucalypts but kindred to them there are two hardwoods of outstanding quality. These are "Turpentine" and "Brush Box" (*Tristania conferta*).

Turpentine is a tree of great value, and its suitability for afforestation purposes should be widely tested in all our southern lands.

The Turpentine belongs to the coastal districts of New South Wales and Southern Queensland.

Size and Form.—It is an exceedingly handsome tree, reaching a height of 200 feet and a diameter of as much as 10 feet or more, and with a magnificent straight branchless bole reaching to a great height. The taper is rather more than in the case of most of the Australian great trees.

The bark is of a reddy brown, thick, and matted, and is supposed to play a very important part in resisting attacks by marine worms when the timber is used for piles, if driven with the bark on and intact.

In addition to its value as a timber producer, it is a very handsome tree suited for beautification and shade purposes.

Rate of Growth.—The late Baron von Mueller described the Turpentine as "rather of quick growth." Unfortunately there is practically no information recorded as to its rate of growth or best sylvicultural treatment. Judging rate of growth by the number of annual rings to the inch recorded in connection with trees or pieces of timber selected for test purposes is of little, or practically no value, for their is a lack of information as to the conditions under which such trees have grown—whether their diameter growth has been retarded by over density or other cause, or accelerated by having an excess of room or exceptionally favourable conditions. The only absolutely reliable guide is that supplied by data recorded from growth under actual forest conditions, and where the date of planting is known.

However, there are some indications, though meagre, that von Mueller's statement is to an extent warranted. Some trees show quite satisfactory, though not quick, growth, and young plants are showing what would indicate a medium, not slow, rate.

The Turpentine is such a very valuable tree, producing timber of special quality and of great length that it ought to be given a thorough trial in the different countries in situations where most favourable growth is likely.

Timber.—The timber is hard, tough, close grained, heavy (63 lbs. per cub. foot), strong, and very durable. It has a wide range of utility for such purposes as strong, durable hardwoods serve, but it is more highly prized as a round timber, because of its special qualities, and also because sawmillers dislike it for sawing, as it very quickly blunts the saws.

Its special value is for piles, because it can be procured in much longer lengths than Ironbark, and because of its reputation for resisting attacks of marine worms. That it is a great resister of such under some conditions is undoubted, but it is questioned whether it is so under all conditions. The weight of evidence is that if the piles can be driven with the bark on and intact, from just under the ground up to high-water mark, without any cuts for braces, etc., they will completely resist attack. Next to that it would appear that if the piles are driven intact without any dressing, removal, or break of sapwood within these limits they will be strongly resistant, if not equally to having the bark on. Dressed Turpentine, where removal of sapwood has exposed the heartwood would seem to be the least immune.

It is a valuable timber for poles, posts, and any outside work as well as for general purposes, including structural work, and it has the very valuable quality of being a great resister of fire.

Climate and Soil.—It will not stand a severe climate, requiring warm sheltered conditions, with a fair degree of humidity. Its range in New South Wales and Southern Queensland is well spread, and extends from the coast well into and up the mountains, finding its optimum conditions in deep sheltered gullies with rich free soil.

In its use in afforestations only situations affording such, or nearly such, conditions should be used for it, and the richer and deeper the soil the better. It delights in deep well-sheltered, alluvial river-flats.

Sylvicultural, etc.—Plants are easy to raise, somewhat touchy to transplant, but make fair to good progress as young plants, and therefore get away from the weeds fairly well. It is very questionable whether Turpentine will do well in "pure" plantation. All indications are that it favours association with other species, it forming a small proportion of the whole. It will stand quite a fair amount of shade—there should always be fair top-light—and will grow readily with many different species, such as many of the Acacias, including Blackwood (*A. melanoxylon*).

The Turpentine has at times a tendency to produce several stems. For pole and post timber this does not matter, but when heavier timbers are required, it is undesirable. By careful selection of seed this tendency should be lessened, and the locality from which the seed is collected is important, for the Turpentine, having a fairly wide range from coastal to mountain situations, similarity of situation to where it is to be grown should be chosen from which to collect.

Turpentine thrives in New Zealand in sheltered situations among medium-sized growth on open native forest margins, and might with advantage be planted in such situations, and in ravines, etc., around or interspersing other plantations, where the Turpentine could be left when cuttings of earlier maturing crops were made.

Tristania conferta (The Brush Box).

The Brush Box is, after the very best Eucalypts and the Turpentine, far the most valuable of the large hardwood trees.

Its natural habitat is along the coastal regions of northern New South Wales and Queensland, spread over a fairly wide belt, found in both lowland and poor hilly country, but varies much in size according to situation.

Besides its value for timber, it is much prized for ornamental and shade purposes.

Size and Form.—According to situation it varies in size from not much more than a large shrub to that of a large forest tree, reaching a height of 150 feet and a diameter up to 7 or 8 feet, but usually it is a tree about 100 to 200 feet in height by a diameter of 3 to 4 feet.

It is a very handsome umbrageous tree, with smooth, grey, deciduous bark.

Rate of Growth.—Unfortunately the Brush Box cannot be classed other than as a slow grower, that is as compared with fast growing trees. Growths of from 12 inches to 18 inches a year are recorded, and in some situations no doubt greater rates than those are attained. A tree showing no better rate of growth than that indicated is not worth growing unless it has very exceptional qualities which the Brush Box has.

Timber.—The timber of the Brush Box is of exceptional value, it is hard, heavy (54 lbs. to the cubic foot), tough, close-grained, matted or interlocked, strong, and very durable. It is of value above all timbers for wharf and bridge decking, and all purposes where subjected to much wear. It makes excellent bearings, sleepers, tram rails, mine timbers, wedges, etc. It is a great resister of white ants.

A tree that produces timber of such qualities, even when a slow grower, should be given thorough and extensive trials in suitable situations in afforestation operations in all our southern lands.

Climate and Soil.—The Brush Box will grow on poor hard ridges, but not to dimensions worth while, and to do well it requires much the same climatic and soil conditions as the Turpentine, and although plants raised from trees growing in the higher exposed position might withstand severer conditions on the whole the Brush Box, if anything, requires warmer situations.

Chapter LXVII.

ACACIAS.

Wattles.

The Southern Hemisphere as a whole is poorly endowed in softwoods, doubtless a contributing cause of which is the absence of land within the southern zone equivalent to the zone within which the softwood belt of the north lies; on the other hand it is richly endowed in high-class hardwoods.

Of our southern lands Australia has far the greater supply of hardwoods, many of them of great value and peculiar to the country, for the Eucalypts, of which there are a great number of species—well over 400—and many of other genera are practically confined to Australia. It has also over 300 species of Acacias, a genus which has a very wide distribution over other parts of the world, both in the Northern and Southern Hemispheres.

The Eucalypts embrace many species that are giants, some that are among the leading giant trees of the world.

On the other hand Acacias are mostly from small to medium sized trees, only a few ranking as large forest trees, and none as giants, but many of them produce valuable, and some very beautiful timbers, though mostly in comparatively small sizes.

The qualities and value of most of these timbers have been much overlooked because of the great quantities of other hardwoods of larger size being available. The consequence has been that there has been ruthless destruction and waste. One direct result that has already come about is the passing of the tanning bark trade from Australia to South Africa, where the *Australian* bark wattles are grown, and from which Australia now draws large supplies. South Africa has about 300,000 acres in Wattle.

The wood of a great number of Acacias is hard, strong, and beautiful, but because of its small size its utility does not extend beyond turnery and handles. But there are several species that grow to considerable size, some fit for milling, the

timbers of which have high qualities—hardness, strength, durability, and great beauty, or other qualities that make them valuable.

The following are among the most important, their approximate heights and diameters are given:—

Acacia mollis (Black Wattle), 60 ft. x 2 ft.
,, *melanoxylon* (Blackwood), 100 ft. x 5ft. or 6 ft.
,, *penninervis* (Mountain Hickory), 50 ft. x 2 ft.
,, *Bakeri*, 150 ft. x 4 ft.
,, *glaucescens*, 60 ft. x 2 ft.
,, *salicina* (Cooba), 40 ft. x 2 ft.
,, *excelsa*, 50 ft.
,, *subporosa*, 50 ft.
,, *longifolia*, 50 ft.
,, *harpophylla*, 60 ft.
,, *Cambagei*, 30 ft. x 1 ft.
,, *pendula*, 30 ft.

The value of Acacias in connection with afforestation is far from fully or generally appreciated. It goes far beyond that of their timber or their bark, for various species serve excellently most important purposes in formation of mixed plantations. Mixtures either permanent or temporary. They are great soil improvers, shade givers, and weed destroyers, and fire resisters. They make excellent nurse trees for other species which, perhaps being tender, require protection, or where early density is required or protection from disease. They so improve the soil and forest floor that greater vigour is imparted to the other species composing the mixture. Some of them have the great advantage over most kinds of trees in that they mature early, and so when used as nurses or for removal as comparatively early thinnings, are valuable as round and small-wood, for mine props, poles, fencing, and the best of fuel.

Time for Removal of Bark.—Bark is most easily stripped from Wattles or any trees during the period of the most vigorous growth of the tree—that is during the seasonal period of most vigorous growth. This time is usually during early summer, but it varies with the species and the rainfall.

Bark can be got off during the dormant or semi-dormant seasons, but at such times the operation is far too tedious for bark stripping for tanning purposes.

Acacia mollis (Black Wattle).

From the point of value of timber only, the Blackwood (*Acacia melanoxylon*), not Black Wattle, is the most important, but for general purposes from a tree-planting aspect the Black Wattle is far and away the most valuable.

Unfortunately much loss and disappointment has been caused, and the value of this tree in general estimation much detracted from, by the difficulty in getting reliable seed. That supplied is frequently wholly that of another variety, or is mixed with that of others.

There is a group of Acacias bearing considerable general resemblance, and the seeds of the different varieties of which are almost indistinguishable. The late Mr. Maiden grouped them under the general name decurrens, and divided them into six varieties, viz., normalis, mollis, pauciglandulosa, Leichhardtii, dealbata, and lanigera.

The three varieties that are a matter of concern are (1) normalis, the type known as Sydney Green, (2) mollis, the true Black Wattle, and (3) dealbata, the Silver Wattle.

The latter, the **Silver Wattle,** though growing to a very large tree for a wattle—much larger than the others—is a curse in all plantations into which it is introduced or gets because of its prolific and persistent suckering and sprouting from the stump habit. The seed of this variety is frequently heavily mixed with that of the true Black Wattle. Normalis, the type commonly known as Sydney Green, is a much smaller tree than Mollis, slower growing, more tender, and very heavy headed, and consequently acts quite differently in a mixture from mollis. The seed of the Sydney Green is very frequently supplied in place of that of Mollis, doubtless because it seeds with much greater profusion, is much more easily got at and collected.

Whilst differences cannot be distinguished in the seeds, those in the trees can easily be.

Var. *dealbata*, the Silver Wattle, is a tall growing, somewhat slender, tree, open branched and not densely foliaged. The leaves are small and are of a distinctly silvery-green, and the young tips are of a pale bluey-silvery green, and the roots profusely sucker and the cut stumps sprout. It flowers in July and August.

Normalis is a short growing tree, about 25 to 30 feet—with a rather thin stem, 6 to 9 inches, much branched, dense heavy

dark-headed, foliage dense and dark green, leaves broad, leaflets long and narrow, young tips green. Young wood almost square with almost transparent wide filaments along the corners. Flowers in July and August. Seed matures the same season. Flowers rich golden yellow.

Mollis, the Black Wattle, is a tall growing tree up to 70 or 80 feet high, and with a diameter of up to 2 feet. Much more sparsely branched and foliaged than normalis, leaves smaller, leaflets shorter and closer set. Young sprouts and leaves golden green. Young wood round and without any filament attached. It never suckers or sprouts from roots or stump. Flowers in December. Flowers are pale yellow. Seeds do not mature until flowers of following year are coming. Years ago adulteration of Mollis seed with Dealbata seed used to be the chief trouble, but of late years the sowing of seed of Normalis under the impression that it was that of Mollis has caused endless trouble. In mixtures where Normalis has been planted in error in place of Mollis, with species it was supposed to keep pace with or exceed in growth, it has been left hopelessly behind, and therefore has mostly failed to fulfil its purpose.

The Black Wattle (*A. mollis*) reaches a height of 70 to 80 feet and a diameter of 2 feet, but is more usually a tree of 50 feet with from 10 inches to 18 inches diameter.

If grown properly it is a tall straight-growing tree with a practically clean stem for well over half its height and above the branches are sparse and not heavy. It is a hardy tree, thriving in a great range of climatic and soil conditions, but far the best in deep porous, good soil, with plenty of soil and atmospheric moisture and generous rainfall, but will do with a fairly low rainfall.

Rate of Growth.—It is an exceedingly rapid grower. So rapid that for a number of years it will completely outstrip the Insignis, and will keep pace with the most rapid growing Eucalypts, such as Fastigata, until it reaches about 50 feet, when the Insignis and Fastigata will probably begin to outgrow it.

It has grown 50 feet high and 9 inches diameter 4 ft. from the ground in 7 years in the plantation of the writer, and 45 feet high and 3 inches through "running neck and neck" in dense plantation with E. fastigata in 6 years.*

*Vide Note on page 149 as to effect of mixing A. mollis (Black Wattle) with Euc. fastigata.

Timber and Bark.—The timber is hard, fairly heavy (51 lbs. to cub. foot), strong, fairly tough, splits and dresses easily, and is durable or fairly so—compared to age exceedingly so. It is serviceable for many purposes, as a round or split timber, poles, posts, mine props, fencing—lasting in the ground from 7 to 12 years untreated, and much longer creosoted or even charred and tarred. It is most excellent fuel, one of the very finest. Though small for milling, it is a fine handsome wood for furnishing purposes and such like.

For the farm woodlot, and generally on the farm, it is ideal. In addition to the timber the Black Wattle's bark has great value.

This Wattle's bark does not yield the highest percentage of tannic acid—it yields about 36% tannic acid and about 60% of extract—the Golden Wattle (*A. pycnantha*) yields the highest, but the Black Wattle is a much more rapid grower, growing very much larger and under a much wider range of conditions, and the weight of bark per acre, obtained with less labour, is very much greater.

With the exception of South Africa, labour in our southern lands is a serious weight against the tanning bark industry if unassisted, but if the plantations are so located as to be near a market making intensive forestry practicable, the sylvicultural advantages added to the value of timber and bark worked in conjunction would ensure great direct and indirect advantage from the growing of Black Wattle.

Sylvicultural, etc.—As a shelter or a nurse tree, or one for comparatively early removal in a mixture, there is hardly its equal. It is a great soil improver, affords early great benefit and shelter to the forest floor, destroys weed growth; gives density, shelter, and promotes vigorous growth in a great range of other species. Being a not too great light demander it is not easily injured by trees of other species getting ahead of it where they have been given a considerable start, nor does it injure others in the mixture if it considerably outgrows them, because its top is not dense and keeps a somewhat pyramidal form, and so tends less to suppress the others.

Where the soil is deep and porous the Black Wattle can be interplanted in a fully stocked Insignis plantation in the second or even third year, or planted simultaneously with Insignis, but because of the Black Wattle's rapid development and strong, hard, widespread roots, it must be removed by the eighth or ninth year at the latest.

The Black Wattle can with great advantage be used similarly with other pines, but the pines must be given a start ahead of the Wattles according to their rate of growth. Black Wattle can also with great advantage be used in mixture with many Eucalypts, planting them at the same time or delayed, or for underplanting when necessary thinning of the Eucalypts has opened the forest floor.

Black Wattle seed, in fact most Wattle seed, requires to be left to soak for twelve hours or more in water that has been absolutely boiling when poured on it, or even if the seed is old it will stand actual boiling for a time before being left to soak. The seed can be dried for sowing by mixing in dry sand and gently rubbing.

Sowing *in situ* is best if weeds, animals, and insects do not make it impracticable. That is when the plantation is pure Wattle, but the Wattle seedlings transplant well, provided they are not exposed, are kept wet, and are carefully, firmly, and fairly deeply planted.

The soil need not be rich, but for success it should be deep and porous, not hard, stiff, or impervious either on the surface or below. Unless naturally very free and clean the soil should be ploughed deeply and worked before planting, and cultivating between the rows during the first or even the second year is beneficial.

Experience has shown that the Black Wattle will thrive with wonderful vigour in comparatively poor but mechanically suitable soil properly worked, whilst if planted in the same soil unworked—without ploughing, or then without thorough wide digging of the places for the plants—will almost entirely fail. Soil for Wattle must not have lime in it if the object is production of bark.

Acacia penninervis (Mountain Hickory).

Passing by the Golden Wattle (*A. pycnantha*), because of its small size, the Mountain Hickory is the next of importance from a tanning bark standard, for the bark gives 34% of tannic acid. Further, it grows to a fair size, reaching to from 40 to 50 feet in height and 1½ to 2 feet in diameter, and the timber is of high quality, hard, heavy, dense, tough, durable, and handsome, very much the texture and colour of Blackwood (*A. melanoxylon*), but a little harder.

The Mountain Hickory grows fairly rapidly. When growing independently it is not quite straight stemmed, and becomes

wide spreading with heavy rather crooked limbs. The bark on stems and limbs is hard, thick, and deeply furrowed, rather like the Ironbark Eucalypts. The bark on the outer parts is a bright brown or biscuit colour, and reddish in the furrows.

Mountain Hickory is one of the numerous Acacias having phyllodes in place of leaves, and the phyllodes being broad and falcate it is much more suggestive of a Eucalypt than a Wattle.

When grown under forest conditions the Mountain Hickory is taller and straighter growing. It is hardy and is not very sensitive as to climatic and soil conditions, but thrives best where the soil is free, deep and moist, and where there is a generous rainfall.

Acacia Melanoxylon (Blackwood).

The Blackwood is quite the most important of the Acacias as a timber producer. It grows to a large size, reaching over 100 feet in height and 5 or 6 feet in diameter. When growing in a situation conducive to its larger growth it is a fine handsome, straight clear stemmed tree, with a heavy dense head, but when in exposed situations, or when growing openly unmixed or only slightly mixed with other species, it is generally a short stemmed very much branched tree, reaching much less dimensions. When growing in deep moist gullies, mixed with tall growing trees of other species, it attains to the dimensions of a fine forest tree.

There are two varieties in the Blackwood. The one is a rough hard barked, not quite straight growing tree, the other is a straight growing smooth barked tree. One of them is known in Tasmania as Blackwood, and the other as Lightwood, the smooth barked one, and whilst the latter produces a straighter grained timber, the former is the more handsome grained, and it is supposed that it is from this one that the very highly figured very valuable timber comes.

Timber.—The timber is of very great value, one of the most valuable of Australian timbers. It is strong, dense, close-grained, and very durable. Though close, it is not hard, and is one of the finest timbers to dress and to carve. It cuts cleanly, smoothly, without the least tear in any part. It dresses and polishes beautifully, having a fine satiny sheen. It is beautifully figured, and is of a dark handsome colour.

Blackwood is justly considered one of the very finest timbers for furnishng and cabinet work. On occasions trees are found

with wonderfully figured grain in the timber. Such are of very great value.

Besides being of such great value for furnishing, cabinet work, panelling, fittings, table tops, billiard tables, pianos, and such like, it is also, on account of its strength and durability, suitable, though too valuable, for construction work.

Rate of Growth.—The Blackwood's rate of growth is not rapid but is quite good. It has grown to a height of nearly 50 feet and a diameter of 1 foot 3 inches in 25 years, and it may be taken that it will make an average annual height growth of 1 foot 6 inches or over, and diameter growth of half an inch.

Such a rate of growth for a tree producing such a high class exceedingly valuable timber is highly satisfactory. Where the Blackwood will grow well, and there are very many such places, it should be infinitely more profitable to grow it than to grow slow growing supposedly high class pines, which are being largely planted under the false impression that the timber of young immature trees will compare with that of mature trees. The timber of Blackwood is of good quality and durable when young.

Climate and Soil.—The Blackwood is hardy, will stand quite severe frosts—its natural range is from Queensland, through New South Wales, Victoria, and Tasmania, in the latter country finding its optimum conditions. It will grow in many descriptions of soil, but a good quality of deep porous soil or sandy loam, or deep river silt, suits it best, and plenty of moisture.

Sylvicultural, etc.—Blackwoods are easily raised and transplanted, and although the plants do not appear to make much progress at first they do later, and need less attention than any other species, as they have a peculiar faculty of fighting their way through weeds or other growth, and they become wonderful weed suppressers. Quite the best of all species as complete weed suppressers.

The Blackwood should never be planted "pure." Planted "pure" it will not thrive, even if climatic and soil conditions are favourable, and will not attain timber tree size.

The New Zealand State Forest authorities years ago planted Blackwood "pure" quite extensively, but such proved a complete failure.

Blackwoods should be planted in mixture with kinds that will exceed them in height, but the branches of which will not spread over their tops to exclusion of the light. They grow

well with the Black Wattle (*A. mollis*), planted in alternate rows, or with various Eucalypts and other trees. They thrive well along river flats and banks, and in gullies, and especially well with medium-sized New Zealand native bush.

On no consideration should Blackwood have any branches pruned off, or cut even at some distance from the stem.

It is an excellent fire resister, and is highly suitable for plantation margins, for in addition to being a fire resister it soon completely kills out all undergrowth.

Acacia Bakeri (Baker's Wattle).

Baker's Wattle is the largest of all the Australian Acacias, if not the largest of all Acacias. Richard T. Baker, after whom it was named, states that it is said to reach over 200 feet in height. Its diameter is from 2 to 4 feet. The writer has no knowledge of its rate of growth, but reference to this Acacia is made here chiefly on account of the fact that it reaches the dimensions of a large forest tree, and there are very few really tall growing leguminous trees.

Speaking generally "pure" planting is so undesirable, and the composition of desirable mixtures offers to the forester a problem ever varying with the location (position to the market) and the climatic and soil conditions, and with the tendency of so many species to disease, that leguminous trees, especially very tall growing ones, the products of which are valuable, should be given a thorough trial in all situations that offer any reasonable prospects of success. It always has to be remembered that some, even many, species of trees often show very greatly invigorated growth in new homes. No species should be planted extensively until it has been reasonably tested in the new home, simply on its reputation in its natural home. Equally no species should be passed over without fair trial in a possible new home, simply on account of unfavourable reputation in its natural home or on account of lack of information, if its products are likely to be of value.

Baker's Wattle belongs to New South Wales and southern Queensland—coastal districts—and found at elevations up to 1,000 feet. It is a free, deep, good soil and moisture lover like most others.

Timber and Gum.—The timber is heavy (54 lbs. per cub. foot), hard and strong. It is pale coloured throughout, paler

than any of the Acacias which are usually dark, or rather dark coloured. It has a handsome grain, and is suitable for decorative purposes, turnery, furniture, carriage and coach-building, bearings, etc. The timber more resembles Australian "Teak" than Acacia. The proportion of sapwood is large.

Baker's Wattle exudes a valuable, highly adhesive bright transparent dark amber coloured gum, and if the tree was grown in numbers the gum should have considerable commercial value.

Acacia salicina ("Cooba" or "Koobah").

This is not one of the distinctly coastal-belt Acacias, it belongs more to the interior and has a wide range through South Australia, Victoria, New South Wales, and Queensland. The tree is beautiful and willow-like in form, and is a lover of the riverside. It is very variable in size, ranging from that of a wide-spreading large shrub to a considerable tree of 50 feet height and 2 feet diameter.

Timber.—The wood of this Acacia is very fine, beautiful and valuable. When polished it has an exceedingly handsome rich dark red to dark Honduras Mahogany-like appearance. It is fairly heavy (48 lbs. per cub. foot), close grained, tough, and slightly interlocked, and is suitable for the finest furniture and decorative purposes.

Sandy soil to sandy loam and river deposit, with plenty of soil moisture, suits it best, and it is with such conditions it attains its greatest dimensions.

Where the conditions are somewhat arid it does not exceed the proportions of a shrub.

Acacia harpophylla ("Brigalow").

Unfortunately the Brigalow does not attain large size, it is widely spread in New South Wales and Queensland, and there a most common scrub, but it will reach a height in certain situations of 40 or possibly 50 feet. Did it attain larger dimensions it would be a very valuable tree, for its wood is extraordinarily durable and exceedingly beautiful in grain and colouring. It is heavy (63 lbs. to the cub. foot), hard, strong, and elastic, and splits freely. It is similar in appearance to that of *A. salicina*, though somewhat darker, and is much heavier.

Acacia pendula ("Myall" or "Weeping Myall").

The Weeping Myall, another New South Wales-Queensland Acacia. A rather slender, graceful, somewhat willow-like tree, reaching 30 or perhaps 40 feet in height and a foot in diameter. Unfortunately rather small, for the timber is of exceedingly high quality and very beautiful in grain and colouring. It is extremely hard, heavy (72 lbs. to the cub. foot), close-grained, and tough. It is useful for handles, turnery, decorative and cabinet work.

It thrives on river banks and in wet places.

Acacia Cambagei ("Gidgee").

This is another of the inland Acacias, a medium sized one. It thrives best in sandy or loamy soil, and in such grows in great quantities and does not object to calcareous soils.

Its timber is exceedingly heavy (84 lbs. per cub. foot), close grained, tough, rather interlocked, and extremely durable, and of great strength. It has a beautiful wavy figured grain, dark with a ruddy glow, an exceedingly handsome timber. Much prized for turnery, rods, and any dressed round timber, cabinet work, waggon building, and, on account of its great durability, for fence posts, etc.

Its weight exceeds that of any other Acacia and of any Eucalypts.

Acacia glaucescens ("Coast Myall").

The Coast Myall is one of the larger of the Acacias, reaching 60 feet in height and 2 feet in diameter.

Its range is well up in the coastal ranges from the south of New South Wales into Southern Queensland.

It is a very handsome tree, being one of the most beautiful of all the Acacias. Grown alone it is a much-branched very wide spreading, short-stemmed, beautiful ornamental and shade-giving tree. Grown in mixture under more or less forest conditions it assumes taller, straight clear-stemmed proportions.

The **timber** is heavy (62 lbs. per cub. foot), very hard, strong, durable, dark in colour, somewhat resembling English walnut. It is an exceedingly handsome timber. Soil conditions similar to other Acacias suit it best.

Acacia excelsa ("Ironwood" or "Ironwood Wattle").

The Ironwood is a large forest tree, the third largest of all the Acacias, reaching as much as 80 feet or over in height and

3 feet in diameter, with a long clean bole. Grown independently it forms a most graceful tree, with somewhat slender, widespread branches, densely foliaged and slightly drooping.

It occurs in New South Wales and Queensland, inland, and usually near water.

Timber.—The timber is exceedingly hard, therefore the name Ironwood, heavy (63 lbs. to cub. foot), close-grained, interlocked, strong, but not durable in the ground. It is very handsome, beautifully figured. Somewhat similar wood to that of the "Weeping Myall" (*A. pendula*), but lighter in colour, and obtained in larger sizes. It is suitable for similar purposes for which the other strong, hard, handsome Acacia timbers are used

The quality of its timber and the large size to which the Ironwood grows makes it advisable to thoroughly test its suitability in connection with afforestation in certain parts. It is a most excellent firewood. In fact all Acacias provide excellent fuel.

Chapter LXVIII.

PULPWOODS.

In our southern lands some of the State Forest Services, many Forestry Companies, and others, are looking to the manufacture of wood-pulp to play an important part in providing a market for the produce of their plantations.

In the present it is very difficult to judge how much warrant there is for such anticipations, anyway so far as it concerns the immediate future, whatever the more distant may have in store.

Doubtless the time will come when the huge consumption of softwood and the slow growth of such in the Northern Hemisphere will so deplete supplies, and that values will be so greatly enhanced, that the price, together with the exceedingly rapid rate of growth in our southern lands, will outweigh the high cost of planted forests as against natural grown, the bad location of many, and the very high costs of labour in Australia and New Zealand, though not so high in South Africa.

Location will without doubt prove the most important factor after labour costs, for cheap and easy haulage between forest and mill is essential, for the raw material must be delivered at the mill at very low figures for pulping purposes compared with that for any other purpose. Basing calculations on the present price of newsprint, and the prospects for some considerable time to come, the raw material must be in very large supply at so low a cost at the pulp mill that the stumpage values, even in the case of a good location, would only represent a fraction of the value per acre anticipated by planters, and also of that which may be considered assured from utilization of the timber for any of the other ordinary purposes.

To gather some idea of the comparative values as between timber for ordinary purposes and as material for pulping simply approximate figures will display the position quite sufficiently.

Timber for Ordinary Purposes.—(1) Companies and other planters anticipate stumpage of 5s. per 100 bd. ft. at least, amounting to acreage stumpages ranging from £250 to £500 and upwards. (2) Actual stumpages that have been paid and are being paid range from 2s. 6d. to 5s. per 100 bd. ft., and in some cases much higher.

Timber for Pulping Purposes.—(*a*) It is reported that the Tasmanian Company's (Tasmanian Paper Proprietary, Ltd.) lease of 175,000 acres for 99 years provides, among other, for the payment of 2s. per cord stumpage, and as a cord is taken as equal to 500 b. f., 2s. per cord would represent less than 5d. per 100 b. f. (*b*) The average value of pulpwood at Canadian pulp mills is £2 per cord, equal to 8s. per 100 b f. This 8s. per 100 b. f. covers (1) Stumpage, (2) felling, (3) stripping, (4) logging, and (5) haulage to the mill.

What the actual stumpage's proportion would be is hard to say, but it certainly would be an exceedingly small part of the 8s.

It has been suggested that a pulping mill would provide a market for thinnings. Whilst it is impossible to say what may happen some time in the future, a consideration of the conditions and requirements necessary for the production of newsprint at present values would seem to indicate that the utilization of thinnings would be impracticable owing to the greatly increased cost of removal as compared to that of material from clear cutting.

Experience has shown that for successful low cost production of newsprint very large costly plants are necessary. A large plant such as in Canada would produce enough newsprint to supply all the needs of Australia, New Zealand, and South Africa.

The requirements for low cost production are:—

(1) Location on waterfront, water carriage, and large supply of fresh water.

(2) A large constant, regular, supply of suitable raw material.

(3) That the supply should come from clear—not partial—cutting of material, all of practically similar quality.

(4) That the material should be of such as requires a minimum preparatory dressing.

(5) That the felling, preparation, logging, and hauling or carriage to the mill be all at low cost.

(6) That cheap power is available.

High labour rates would of course greatly affect felling, logging, hauling costs, etc., as well as costs in the mill.

Long carriage, except by water, would impose too heavy a charge, and therefore the supplies must be comparatively close to either the mill or water, and the haulage not over rough country.

One comparatively small mill should supply all the needs of, say, New Zealand, and therefore the material only of plantations in close proximity to that one mill could look to pulping as a market.

Whilst there are natural forests in Tasmania which may come within the requirements for production of pulp, and possibly some on the West Coast of New Zealand, there are no plantations in New Zealand, Australia, or South Africa which at present offer any reasonable prospect of supplying the quantity and quality of material at anything like low enough cost.

Whatever change of conditions and circumstances the future may have in store, present conditions indicate the following:—

(*a*) That large supply is requisite, not too far from the pulpmill, and the cost of logging over a given area to remove only a portion of the crop prohibit the use of thinnings for the supply of raw material for pulping.

(*b*) Notwithstanding the rapid growth in our southern lands, the high cost of labour requisite for establishment, maintenance, etc., imposes a stumpage charge beyond that which can be paid for raw material for pulping.

(*c*) Unless the conditions are extraordinarily exceptional a much higher stumpage can be paid for timber for saw purposes than a pulp-mill can afford to pay.

(*d*) So far as affecting Australia and New Zealand, the high wages and other costs in connection with felling, logging, and haulage to the mill impose too heavy a charge on the raw material to make possible delivery at the mill at a sufficiently low cost for pulping purposes.

LOG RULE.

For Round Timber.
Based on Quarter Girth Measure.

Cir. in Feet	Length of Log in Feet.											
	8	10	12	14	16	18	20	22	24	26	28	30
ft. in.	B.F.	B.F.	B.F.	B.F.	B.F.	B.F.	B.F.	B.F.	B.F.	B.F.	B.F.	B.F.
3 0	53	67	81	94	108	121	135	148	162	175	189	202
3 1	56	71	86	100	114	128	143	157	171	185	200	214
3 2	60	75	90	105	120	135	150	165	180	196	211	226
3 3	63	79	95	111	127	143	158	174	190	206	222	238
3 4	66	83	100	117	133	150	167	183	200	217	233	250
3 5	70	88	105	123	140	158	175	193	210	228	245	263
3 6	73	92	110	129	147	165	184	202	220	239	257	276
3 7	76	96	116	135	154	173	193	212	231	250	270	289
3 8	80	101	121	141	161	181	202	222	242	262	282	302
3 9	84	105	127	148	169	190	211	232	253	274	295	316
3 10	88	110	132	154	176	198	220	242	264	287	309	331
3 11	92	115	138	161	184	207	230	253	276	299	322	345
4 0	96	120	144	168	192	216	240	264	288	312	336	360
4 1	100	125	150	175	200	225	250	275	300	325	350	375
4 2	104	130	156	182	208	234	260	286	312	339	365	391
4 3	108	135	163	190	217	244	271	298	325	352	379	406
4 4	112	141	169	197	225	253	282	310	338	366	394	422
4 5	116	146	176	205	234	263	293	322	351	380	410	439
4 6	121	152	182	213	243	273	304	334	364	395	425	456
4 7	126	158	189	221	252	284	315	347	378	410	441	473
4 8	130	163	196	229	261	294	327	359	392	425	457	490
4 9	135	169	203	237	271	305	338	372	406	440	474	508
4 10	140	175	210	245	280	315	350	385	420	456	491	526
4 11	144	181	218	254	290	326	363	399	435	471	508	544
5 0	149	187	225	262	300	337	375	412	450	487	525	562
5 1	155	194	233	271	310	349	388	426	465	504	543	581
5 2	160	200	240	280	320	360	400	440	489	521	561	601
5 3	165	207	248	289	331	372	413	455	496	537	579	620
5 4	170	213	256	299	341	384	427	469	512	555	597	640

LOG RULE—continued.

For Round Timber.

Based on Quarter Girth Measure.

Cir. in Feet.		Length of Log in Feet.											
		8	10	12	14	16	18	20	22	24	26	28	30
		B.F.	B.F.	B.F.	B.F.	B.F.	B.F.	B.F.	B.F.	B.F.	B.F.	B.F.	B.F.
5	5	176	220	264	308	352	396	440	484	528	572	616	660
5	6	181	227	272	318	363	408	454	499	544	590	635	681
5	7	187	234	281	327	374	421	468	514	561	608	655	701
5	8	192	241	289	337	385	433	482	530	578	626	674	722
5	9	198	248	298	347	397	446	496	546	595	645	694	744
5	10	204	255	306	357	408	459	510	561	612	664	715	766
5	11	210	263	315	368	420	473	525	578	630	683	735	788
6	0	216	270	324	378	432	486	540	594	648	702	756	810
6	1	222	278	333	389	444	500	555	611	666	722	777	833
6	2	228	285	342	399	456	513	570	627	684	742	799	856
6	3	234	293	352	410	469	527	586	645	703	762	820	879
6	4	240	301	361	421	481	541	602	662	722	782	842	902
6	5	247	309	371	432	494	556	618	679	741	803	865	926
6	6	253	317	380	444	507	570	634	697	760	824	887	951
6	7	260	325	390	455	520	585	650	713	780	845	910	975
6	8	266	333	400	467	533	600	667	733	800	867	933	1000
6	9	273	342	410	478	547	615	683	752	820	888	957	1025
6	10	280	350	420	490	560	630	700	770	841	911	981	1051
6	11	287	359	431	502	574	646	718	789	861	933	1005	1076
7	0	293	367	441	514	588	661	735	808	882	955	1029	1102
7	1	300	376	452	527	602	677	753	828	903	978	1054	1129
7	2	308	385	462	539	616	693	770	847	924	1002	1079	1156
7	3	315	394	473	552	631	710	788	867	946	1025	1104	1183
7	4	322	403	484	565	645	726	807	887	968	1049	1129	1210
7	5	330	413	495	578	660	743	825	908	990	1073	1155	1238
7	6	337	422	506	591	675	759	844	928	1012	1097	1181	1266
7	7	344	431	518	604	690	776	863	949	1032	1121	1208	1294
7	8	352	441	529	617	705	793	882	970	1058	1146	1234	1322
7	9	360	450	541	631	721	811	901	991	1081	1171	1261	1351
7	10	368	460	552	644	736	828	920	1012	1104	1197	1289	1381
7	11	376	470	564	658	752	846	940	1034	1128	1222	1316	1410
8	0	384	480	576	672	768	864	960	1056	1152	1248	1344	1440
8	1	392	490	588	686	784	882	980	1078	1176	1274	1372	1470
8	2	400	500	600	700	800	900	1000	1100	1200	1301	1401	1501
8	3	408	510	613	715	817	919	1021	1123	1225	1327	1429	1531
8	4	416	521	625	729	833	937	1042	1146	1250	1354	1458	1562
8	5	424	531	638	744	850	956	1063	1169	1275	1381	1488	1594
8	6	433	542	650	759	867	975	1084	1192	1300	1409	1517	1626
8	7	442	553	663	774	884	995	1105	1216	1326	1437	1547	1658
8	8	450	563	676	789	901	1014	1127	1239	1352	1465	1577	1690
8	9	459	574	689	804	919	1034	1148	1263	1378	1493	1608	1723
8	10	468	585	702	819	936	1053	1170	1287	1404	1522	1639	1756
8	11	476	596	716	835	954	1073	1193	1312	1431	1550	1670	1789
9	0	485	607	729	850	972	1093	1215	1336	1458	1579	1701	1822

Table Showing the Amount of Forest Capital Involved.

At 1 to 80 years, at 5% interest, for every £1 of Expenditure on Land, Establishment and other First Costs and for every 10s. per annum expenditure for Maintenance, Rates, Taxes, Overhead and other annual charges.

At 5 per cent.

In Years	Per acre £1 First Costs amount to	Per acre 10s. Annual Costs amount to	In Years	Per acre £1 First Costs amount to	Per acre 10s. Annual Costs amount to
1	1·050	·500	41	7·391	63·969
2	1·102	1·025	42	7·761	67·615
3	1·157	1·576	43	8·149	71·496
4	1·215	2·155	44	8·557	75·571
5	1·276	2·767	45	8·985	79·350
6	1·340	3·400	46	9·434	84·342
7	1·407	4·071	47	9·905	89·059
8	1·477	4·774	48	10·401	94·012
9	1·551	5·513	49	10·921	99·213
10	1·628	6·288	50	11·467	104·674
11	1·710	7·103	51	12·040	110·407
12	1·795	7·958	52	12·642	116·428
13	1·885	8·856	53	13·274	122·749
14	1·979	9·799	54	13·938	129·386
15	2·078	10·789	55	14·635	136·356
16	2·182	11·828	56	15·367	143·624
17	2·292	12·920	57	16·135	151·357
18	2·406	14·066	58	16·942	159·425
19	2·526	15·269	59	17·789	167·894
20	2·653	16·532	60	18·679	176·741
21	2·785	17·859	61	19·613	186·131
22	2·925	19·257	62	20·593	195·938
23	3·071	20·715	63	21·623	206·234
24	3·225	22·251	64	22·704	216·046
25	3·386	23·868	65	23·839	228·399
26	3·555	25·556	66	25·031	240·318
27	3·733	27·334	67	26·283	252·834
28	3·920	29·201	68	27·597	265·976
29	4·116	31·161	69	28·977	279·775
30	4·321	33·219	70	30·426	294·264
31	4·538	35·380	71	31·947	309·477
32	4·764	37·649	72	33·545	325·451
33	5·003	40·031	73	35·222	342·223
34	5·253	42·533	74	36·983	359·835
35	5·516	45·160	75	38·832	378·326
36	5·791	47·918	76	40·774	397·743
37	6·081	50·814	77	42·813	418·130
38	6·385	53·854	78	44·953	439·536
39	6·704	57·047	79	47·201	462·013
40	7·039	60·399	80	49·561	485·614

ACACIAS.

Scientific Name.	Common Name.
Acacia Bakeri	Baker's Wattle
,, *Cambagie*	Gidgee
,, *decurrens* var *mollis*	Black Wattle
,, *decurrens* var *normalis*	Sydney Green or Sydney Golden Wattle
,, *excelsa*	Ironwood
,, *glaucescens*	Myall, Boree, Rosewood also Brigalow
,, *harpophylla*	Brigalow—common
,, *melanoxylon*	Blackwood or Tasmanian Blackwood
,, *pendula*	Weeping Myall
,, *pennínervis*	Mountain Hickory
,, *salicina*	Koubah or Native Willow

CUPRESSUS

Cupressus macrocarpa	Monterey Cypress
,, *lawsoniana*	Lawson's Cypress or Port Orford Cypress
,, *lusitanica*	———

EUCALYPTS.

Arranged in Groups under names indicative of superficial characteristics.

Ashes.

Eucalyptus gigantea, syn. *Delegatensis*	Southern Mountain Ash
,, *oreades*	Mountain Ash
,, *Sieberiana*	Victorian Mountain Ash
,, *Smithii*	White Top or Gully Ash

Blackbutts.

Eucalyptus pilularis	Blackbutt

Boxes.

Eucalyptus Bosistoana	Red Box or Bosisto's Box
,, *polyanthenios*	Red Box
,, *Rudderi*	Coast Box

Gums.

Eucalyptus acerrula	Tasmanian Red Gum
,, *cornuta*	Yate
,, *corynocalyx*	Sugar Gum
,, *globulus*	Blue Gum—common
,, *goniocalyx*	Mountain Gum
,, *Gunnii*	Cider Gum
,, *loxophleba*	York Gum
,, *maculata*	Spotted Gum
,, *Maideni*	White Gum or Blue Gum
,, *Muelleri* (Syn. *Johnstoni*)	Mueller's Gum—Tasmania
,, *redunca*	Wandoo
,, *regnans*	Giant Gum
,, *rostrata*	Red Gum or Murray River Red Gum
,, *saligna*	Sydney Blue Gum
,, *salmonophloia*	Salmon Gum
,, *Stuartiana*	Apple Gum
,, *tereticornis*	Forest Red Gum
,, *Viminalis*	Manna Gum

IRONBARKS.

Eucalyptus paniculata	..	White or Grey Ironbark
,, *siderophloia*	..	Broad-leaved Ironbark
,, *Sideroxylon*	..	Narrow-leaved Ironbark

MAHOGANIES.

Eucalyptus acmenioides	..	White Mahogany
,, *botryoides*	..	Bangalay or Bastard Mahogany
,, *diversicolor*	..	Karri
,, *marginata*	..	Jarrah
,, *resinifera*	.	Red Mahogany
,, *robusta* ..	..	Swamp Mahogany

PEPPERMINTS.

Eucalyptus amygdalina	..	Black or Tasmanian Black Peppermint
,, *piperita* ..	..	Sydney Peppermint

STRINGYBARKS.

Eucalyptus Blaxlandi	..	———
,, *capitellata*	..	Brown Stringybark
,, *eugenioides*	..	White Stringybark
,, *fastigata* ..	..	Gum topped Stringybark
,, *Muelleriana*	..	Yellow Stringybark
,, *obliqua* ..	..	Stringybark or Messmate

TALLOW-WOOD.

Eucalyptus microcorys	..	Tallow-wood

WOOLLYBUTTS.

Eucalyptus longifolia	..	Woollybutt
,, *Macarthuri*	..	Camden Woollybutt

PINES.

Pinus Austriaca ..	..	Austrian or Black Pine
,, *Canariensis* ..	..	Canary Island Pine
,, *halepensis* ..	..	Aleppo Pine
,, *laricio* ..	..	Corsican Pine
,, *muricata* ..	..	Bishop's or Prickly Cone Pine
,, *patula* ..	..	A Mexican Pine
,, *pinaster* (syn. *Maritima*)		Cluster Pine
,, *ponderosa* ..	..	Western Yellow Pine
,, *radiata* (syn. *insignis*)		Monterey Pine
,, *rigida*	..	Pitch Pine—Northern
,, *strobus* ..	..	White Pine of the Eastern States
,, *sylvestris* ..	..	Silver or Scots Pine
,, *taeda*	..	Loblolly or Old-Field Pine
,, *Torreyana* ..	..	A Mexican pine
Pseudotsuga taxifolia	..	Oregon, Douglas Fir, Pine or Spruce
Sequoia sempervirens ..	..	Redwood or Californian Redwood
Taxodium distichum ..	..	Bald or Swamp Cypress
Thuya plicata (syn. *T. gigantea*)		Western Red Cedar or Arbor-vitæ

MYRTACEÆ.

Syncarpia laurifolia ..	..	Turpentine
Tristania conferta ..	..	Brush Box

SPECIES INDEX

INDEX

Printed by Whitcombe & Tombs Limited— 98290